THE ART OF GUNNERY,

Robt How his book 1673

Robt How: 1673

Wherein is set forth a number of serviceable secrets, and practicall conclusions, belonging to the Art of Gunnery, by Arithmetick skill to be accomplished: both pretty, pleasant, and profitable for all such as are professors of the same Faculty.

Compiled by *Thomas Smith* of Barwick upon Tweed Souldier.

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To the Right Honourable *PEREGRIN BERTY* Knight, Lord Willoughby, Beak, and Earsby, Lord Governour of Her Majesties Town and Castle of *Barwick* upon Tweed, and Lord Wardon of the East Marches of *England*, for and anempst *Scotland*, &c.

IT is a common opinion, Right Honourable, amongst a great number, who may be termed more wayward then wise, that the Art of Souldiery may perfectly be attained in two or three months practise, and that any common man in a few weeks training, having seene two or three skirmishes may be called an expert souldier. Not considering that a Mariner may saile seven yeares, and yet be farre from a Navigator. A number of mechanicall Artificers may labour divers years, and yet be farre from perfection; and a number of souldiers may serve many years, and yet have but the bare name of a souldier: he may well be called a trained souldier, that knoweth by the sound of Drum and Trumpet, without any voice, when to march, fight, retire, &c. that is able in marching, embattelling, encamping, and fighting, and such like, to performe, execute, and obey the lawes and orders of the field, that hath some sight in the Mathematicals, and in Geometricall Instruments, for the conveying of Mines under the ground, to plant and mannage great Ordnance to batter or beat down the walls of any Town, or Castle, that can measure Altitudes, Latitudes, and Longitudes, &c. such a one may be tearmed in my opinion an expert souldier, though he never buckled with the enemy in the field.

Such perfections is well known to be in your Honour, that you are furnished with those and many more rare qualities in the Art Military, and above all with wisedome and Noble courage, to perform and execute any Honourable enterprise whatsoever for the honour and service of God, your Prince, and Countrey, the which our proud enemies have felt to their paine and your everlasting fame.

And although I my selfe be but one of the meanest souldiers in this Garrison now under your Lordships Government (whom we pray long to govern over us) being brought up from my childehood under a valiant Captaine in Military profession, in which I have had a desire to practise and learne some secrets touching the orders of the field, and training of Souldiers: as also concerning the Art of mannaging and shooting in great Artillery. I have thought it good (hearing of no other that hath done the like before) to frame together certaine Arithmeticall and Geometricall rules, to shew in part how necessary Arithmetick and Geometry is for our profession, the which I have set downe in two little bookes: the one entituled Arithmeticall Military Conclusions; the other, The Art of Gunnery. The first I wrote two or three years since, and bestowed on my Captaine, Sir **Iohn Carie** *Knight, the which (God sparing life) I meane to correct and enLarge, and perhaps put to the Presse: This other I have thought it my part to offer to your Lordships good consideration, to be shrouded under your Honourable buckler, to beare off the blows of envious tongues, which are ever ready to spit their spight against any vertuous exercise: which although it be unworthy to passe under so honourable a protection, I hope your Lordship will in indifferent ballance weigh my willing minde, to doe my Countrey good, and your Honour any service my poore ability is able to performe; which if your Honour allow of, I shall think my paines well employed, and shall encourage me hereafter to bring this new found Art into some better perfection, so farre as my poore ability is able to put in practise, or my simple skill in the Art will reach to. Thus loth to be tedious, I cease, beseeching God to preserve your Honour with much encrease of Honour, to Gods glory, and your hearts desire.*

Your Honours dutifully
at command,

Thomas Smith **Souldier.**

To

To all Gentlemen, Souldiers, Gunners, and all Favourers of Military Diſcipline, *Thomas Smith* wiſheth encreaſe of happineſſe.

GEntlemen, there was never Author, nor practiſed Gunner ever able (as I am perſwaded) to deſcribe at full, or could ſhew perfectly the efficacy and force that Gunpowder is able to accompliſh, it being a mixture of ſuch a wonderfull operation and effect, as by daily experience we finde. And although divers men in divers ages, have invented divers engines and Ordnance for offenſive and defenſive ſervices by gunpowder to be performed; yet none hath, nor could ever attaine to that full perfection, to know preciſely what ſtrange effects the ſaid mixture is able to work. Alſo divers learned men have invented many excellent rules pertaining to the Art of *Gunnery*, and a great many of them have and doe erre in the principals of their inventions: and the cauſe is, for want of due practiſe therein. For the Art of *Gunnery* doth require great practiſe and experience to declare the rare ſecretts thereof; which is not for meane men to attaine to, for that the charge is great.

And albeit, I am the leaſt able of a great many to take any matter in hand pertaining to the ſame Art, being but a ſworne ſchollar thereto, and my ability farre unable to put in practiſe that I would; yet becauſe I have ſerved a prentizehood twice told ſince I took my oath, and never hearing of any that hath compiled any Arithmeticall rules or ſecrets (which is the fountaine head from whence all Arts or ſciences do ſpring) into one volume, I thought it my part and duty (according to my skill) to do the beſt I could therein, for the benefit of others, and that in the plaineſt manner I could, that ſuch as are not well ſeene in numbers Art, might the ſooner underſtand the ſame. And albeit I have herein ſhewed but a few Arithmeticall concluſions belonging to the Art of *Gunnery*, yet the experienced *Gunner*, or skilfull Mathematician, by theſe few may deviſe a great many moe, for ſervice offenſive and defenſive, by Arithmetick and *Geometry* to be performed.

All which concluſions (gentle Readers) I have thought beſt to frame in eaſie Queſtions, ſhewing the Anſwers or Reſolutions thereof. And although they bee but meanely framed, I hope you will accept the ſame in good part, the rather, for that they are a young Gunners practiſes. And if there be ought herein that may profit you, yeeld me your friendly cenſure, I crave no more: or if in any place I have erred, either gently correct it, or paſſe it with ſilence, or in friendly ſort admoniſh me thereof, I deſerve no leſſe.

There are a great many that can ſpie a mote in another mans eye, that had need to have a beame pulled from their owne: ſome will ſcan very curiouſly, and ſooner finde two faults then amend one. If you be of that minde (friendly Readers) I minde not to make you my Iudges.

The widowes mite was as well accepted as the gifts of the wealthy. A ſouldier in *Alexanders* camp, in the dry deſart, preſented to the King his helmet full of cold water, ſaying, if I could have gotten better drink, your Grace ſhould have had part: the which the King gently accepted and liberally rewarded, anſwering, I weigh not thy gift, but thy willing minde. But I ſeek no reward for my travell, but only you will weigh my minde is willing to doe my Countrey good, and to profit the Readers: and not to carp with *Momus*, nor diſdaine with *Zoilus*, nor ſooth with *Zantippus*. In ſo doing you ſhall encourage me to ſet pen to paper, and to flie a higher pitch pertaining to this new found Art. Otherwiſe, if you ſpit out your ſpight againſt me for my good will, I will as meanly account of your malice, and ſo as I finde you, look to have of me.

From my poore houſe in Barwick upon Tweed this 2. of May, 1600.

Your friend and welwiller

Thomas Smith Souldier.

PETER LUCAS Cannonier, in Commendation of the Author and his Book.

SHake ſilly pen to write of Art, to him where Art doth dwell,
And ſay, the want of Eloquence doth ſo thy hand repell,
That farre thy Muſe unable is to praiſe the Authors skill:
Nor canſt thou paint thy minde, nor finely tell thy will.
But as there needs no ſigne at dore, whereas the wine is pure,
So need not I commend this worke, it all men will allure
To love the Smith that forg'd this work, who hath ſuch Art in ſtore,
That better is then Art which trieth gold from ore:
As our proud foes have found, and felt by Ordnance might,
And aid of the Almighty Iove, who doth defend our right.
Therefore good Zeale goe poſt-haſte unto Fame,
And bid her give this Book an everliving name.

Peter Lucas Gunner.

RICHARD HOPE Gentleman in commendation of the work.

TO tell a tale without authority,
Or faine a fable by invention,
The one proceeds of quick capacity,
The other ſhewes but ſmall diſcretion.
Who writes concluſions how to uſe a peece,
In my conceit deſerves a golden fleece.

Who takes in hand to write of worthy warre,
And never marcht where any warre was made,
Nor never hopes to come in any jarre,
But tels the triall, knowing not the trade:
To write of warre, and note not what it is,
May well be thought a work begun amiſſe.

But he that by his ſtudie makes it knowne,
What thing warre is, and whereof it proceeds,
Defenſive and offenſive reaſons ſhewing,
To thoſe that gape for honour by their deeds:
A worthy worke who doth not count the fame,
In my conceit he doth a Souldier ſhame.

If.

If ſo: Smiths travell cannot well offend,
For ſo he meant before he ſet it forth,
And if it chance to come where Souldiers wend,
He it commands to ſeeme of little worth:
For what he writes, he writes to honour theſe,
Which wade in warres to triumph over foes.

Richard Hope Souldier.

RICHARD ROTHERUPPE Gentleman in commendation.

THat man whom Martiall attempts
May raiſe to honour high,
Let him peruſe with learned skill
Smiths *work of Gunnery.*

That Fountaine which ſuch ſprings ſends forth,
Can never dry remaine:
I meane the ground of Arts, from which
All ſcience we attaine.

As Grammer, Muſick, and Phiſick,
With high Aſtronomie.
And other Arts Mathematick,
And brave Geometry:

This Art of Gunnery likewiſe,
Amongſt the reſt let ſtand,
Whoſe God-father this Author is,
Which took the ſame in hand.

Whoſe knowledge in this famous Art,
Deſerves eternall fame:
For his Concluſions excellent
Doth well deſerve the ſame.

Richard Rotheruppe Souldier.

THE ART OF GUNNERY.

A Table ſhewing the deminite parts uſed for menſuration.

FOraſmuch as ſome of theſe meaſures are to be uſed in the Treatiſe following, it is requiſite that I ſhew what kinde of meaſures are commonly uſed, and now in force; beginning with a barley corne, from whence all theſe hereunder, and a great many moe doe proceed, as

An inch		3 barley cornes laid end to end.
A finger breadth		4 barley cornes in thickneſſe.
A hand breadth		4 fingers.
A foote		12 inches.
A yard		3 féete.
An ell		5 quarters of a yard.
A ſpan		3 handbreadths.
A foote		4 handbreadths.
A geometricall pace		5 féete.
A fadome		6 féete, or 2 yards.
10 fadome		A ſcore, or 20 yards.
A furlong		123 paces.
Our Engliſh furlong	containeth	132 paces, or 660 féete.
A pearch or rod		5 yards ½, or 16 féet ½.
An aker		160 perches, 528 paces, or 2640 féete.
A league (mile		1500 paces.
An Italian or Engliſh		8 furlongs, or 1000 paces, or 5000 féet.
A Germane mile		32 furlongs.
A ſcore		20 yards.
An hundreth		600 féet, after 5 ſcore to the 100.
24 grains of wheate		one peny of Troyes weight.
20 pence (dry		one ounce.
12 ounces		one pound.
20 grains of barley		one ſcruple of haberdepois weight.
3 ſcruples		one dramme
8 drammes		one ounce
16 ounces		one pound
112 pound		100 weight
A tonne		20 hundreth

A Table shewing how to weigh a great deale with few weights.

You may weigh any number of pounds from

- one to 40 with these 4 weights: 1. 3. 9. 27.
- one to 121 with these 5 weights: 1. 3. 9. 27. 81.
- one to 364 with these 6 weights: 1. 3. 9. 27. 81. 243.

This rule of weighing many things with few weights proceedeth of Geometricall progression. The pounds to be weighed, are weighed with as many namelike weights, to be done either double or threefold, sometime by adding one weight to another, and sometimes by taking away and adding to the contrary ballance. Example in a double respect; All termes to 15 are weighed with 4 weights of pounds, as 1. 2. 4. 8. so in a triple respect, all pounds to 40 may be weighed with 4 weights, as 1. 3. 9. 27. All pounds from 1 to 364 are to be weighed with these six weights, 1. 3. 9. 27. 81. 243. and so infinitely.

Measures.

The variety of measures are in a manner infinite, and yet are all comprehended under three generall kindes, proceeding from a point in Geometry, as Arithmetick doth from an unite; that is to say, Lines, Superficies, Bodies.

Lines having but only length, without breadth of thicknesse, doe measure only Altitudes, Latitudes, and Longitudes, &c.

Superficies, being limited by lines, bearing length and breadth, without depth or thicknesse, in these are knowne the contents of Pavements, Glasse, Board, Land, &c.

Bodies, being bounden by Superficies, and containing length, breadth, and thicknesse, doe make knowne the quantity of all solid or massive things, as timber, stone, &c. All which requires the aide of Arithmetick, to be truly measured. The definitions, termes, and orderly working of these and all other, the Elements of Geometry will teach you.

Here

Here I thought to have written briefly, or rather to have glanced at the wonderfull strange effects that Arithmetick is able to work and attaine to; but finding that that learned and famous man Master Iohn Dee, in his Mathematicall preface upon Euclids Elements, doth notably touch the same, shewing the rare properties and incredible mysteries that numbers Art can reach to; affirming that the effects thereof, of man, are not fully to be declared; it some struck me in the dumps, feeling my selfe farre unable to soare so high.

How to find the cubicall radix or root of any number.

AS in my Book of the Art of warre, entituled Arithmeticall military conclusions, I began with the extraction of square roots, being a speciall rule to work divers feats belonging to the said Art: So in this Treatise I have thought best to begin and shew how to extract Cubick roots, for that divers conclusions are to be done by the said rule, in the work following, letting passe all former rules, as lesse necessary, the which are commonly knowne to every childe that hath any sight in the Art of numbring.

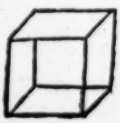
To finde the radix or root cubicall of any number, you must note how many figures or numbers be in the totall summe thereof, and then, as is shewed in the rule, how to extract the square root of any number, you make a prick or point under every other number, beginning at the first number towards your right hand: even so in this rule, in searching for the cubicall root of any number, you must put a prick under the first number towards your right hand, and so encrease your number of pricks under every third number towards your left hand, and your quotient will containe so many figures as there be pricks.

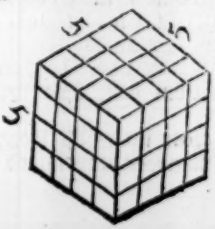
If your number propounded be cubicall, multiply your quotient cubically, the product of that multiplication will be the number that was propounded.

To multiply cubically, you must doe as this example sheweth, 5. multiplied in himselfe, is 25. which 25 multiplied againe by 5, makes 125, and is a cubick number.

A cubicall figure is proportioned as these figures shew, for a cube is a solid body of six equall squares, or lyes like a die.

Example.





It is requiſite in learning to extract roots, to have in perfect memory all thoſe cubick roots of digit numbers, and the cubes they doe make; the which will be a great help in working, the which I have here ſet downe in a Table after M. Records order.

1	1
2	8
3	27
4	64
5	125
6	216
7	343
8	512
9	729

Now to ſeeke for the firſt figure or root, your Table will ſhew you what number ſhall ſtand in the quotient, being due to the laſt prick towards your left hand; which figure ſo ſet in the quotient multiplied cubickly, if it be equall to the number or numbers above that laſt prick, it doth ſhew that the ſaid number or numbers are cubick; but if it be more then a cube number, then abate the greateſt cube number that the quotient will make from the ſaid numbers, and cancelling the ſame, let the remaine ſtand over the head of the ſaid numbers, as is done in diviſion of common numbers, and ſo have you done with the firſt prick.

Secondly, triple your root, ſetting the ſaid tripled number one place nearer from the laſt prick, towards your right hand.

Thirdly, multiply the ſaid triple by the ſaid quotient, the numbers ariſing thereof is your deviſor, to ſet under your firſt tripled number.

Fourthly, finde out a number to be placed in your quotient, that may ſhew how often times your deviſor is contained in the dividend, or numbers ſo remaining over it.

Fifthly, you muſt multiply your deviſor, by the number laſt placed in your quotient, firſt drawing a line under your deviſor, and that which ariſeth of the ſaid multiplication muſt be placed under the ſaid line.

Sixthly, you muſt ſquare the number laſt placed in your quotient, and multiply the ſaid ſquare by the triple of your firſt quotient number, and the ſumme ariſing of that multiplication, ſet under the line one place nearer towards your right hand.

Seventhly, multiply the number laſt placed in your quotient cubickly, and ſet the ſame cube numbers under the line, beneath the other numbers, one place nearer towards your right hand: and then drawing a line under the ſame, adde all thoſe numbers together; the ſumme ariſing abate from the other prick that ſtands towards the right hand in your dividend, and if nothing remaine, the number propounded is a cubick number: But if any thing remaine, the number propounded is no cubicke number; but yet the quotient doth ſhew the neareſt cubick rote in the propoſition.

In this order you muſt worke by every prick, how many figures ſoever the numbers propounded containe.

To

To finde a Denominator to the cubick remaine.

If the number propounded bee not cubicall, and that you desire to know the true denominator to the cubicall remaine, you must square your cubick rot, and then triple the said square, and after triple the rot, adding all those summes together, and to the totall of the said addition, adde one unity, so have you the true denominator cubicall, the which you may abbreviate into lesser termes by Abbreviation, according to your desire.

Or you may finde the denominator cubicall by multiplying the rot in the triple of another number that is more by one unite, nor the said rot: and then adding one unite to the product of the said multiplication, you have your desire.

An example how to work to finde the cubick root.

Admit the summe or numbers, whose cubick rot you desire to know, be 32768, I set the prick under 8, and under the figure 2 standing in the fourth place, as in the work here you may see; and I finde that the greatest cubick number in 32 is 27, and 3 is his rot, which 3 I place in the quotient, and his cube being 27, I subtract from 32, so resteth 5. And so I have done with the first prick towards my left hand, as here in the work you may see.

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  05
  ..
  32768 ( 3
  ..
  27
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Then I triple the quotient 3, and it is 9, which I set one place from the last prick nerer towards my right hand. And then I multiply the triple of the quotient being 9, by the said quotient 3, ariseth 27, the which I place under 57, drawing a line under my devisor 27, and then I seek how oft I can have 27 the devisor in 57, which is a part of the dividend, the which I can have but 2 times, which 2 I place in the quotient, and by the said 2 I multiply the devisor 27, so ariseth 54, which I place under the line under the devisor, as here you see.

```
  05
  ..
  32768 (32
  ..
    9.
  27
  ---
  54
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And then I square the number last placed in the quotient, being 2, and it is 4, which square I multiply by the triple of the first quotient number being 9, ariseth 36, which I place under 54, one place nerer towards the right hand, as here you may see. And then multiplying the digit 2, cubickly ariseth 8, to be set under the line, one place nerer towards the right hand, and adding all these summes together, there ariseth 5768; the which subtracted from the number belonging to the first prick, there remaineth nothing; so I say that 32768 is a cubick number, and 32 is the true rot thereof. You may prove it by multiplying the quotient cubickly, and abating the product from the number propounded, there will remaine nothing.

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  0
  .
  05000
  ..
  32768 (32
  ..
  27
  ---
  54
   36
     8
  ----
  5768
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To finde the neareſt root of a number not cubick.

Queſtion.

I demand the true cubick rat of 117884.

Reſolution.

The pricks placed in order as before, I finde there will be but two figures in the quotient, and that the cubick number of 117 is 64, whoſe cubick rot is 4, which 4 I place in the quotient, and his cube 64 being abated from 117, there remaines 53 to be placed ober the laſt prick: then tripling the quotient 4, ariſeth 12 to be ſet down one place nearer towards my right hand, and then multiplying the quotient by the ſaid triple, doth ariſe 48 for a deviſor, which I ſet in his place, drawing a line under him, as in the former work you ſee. And then I make ſearch how oft I can have 48 in 538, which I can have many times, but more then 9 times I muſt not take; and therefore I ſet downe 9 in the quotient, and multiplying the ſame by the deviſor 48, ariſeth 432 to be placed under the line under the deviſor, then I doe multiply the ſaid 9 ſquarely, ariſeth 81, the which multiplied by 12 being the triple of the firſt quotient, ariſeth 972, the which I ſet downe one place nearer towards my right hand; and then I multiply 9 cubickly, ariſeth 729 to bee ſet downe yet one place nearer towards my right hand: and adding all thoſe ſums together, the totall is 53649, which abated from 53884, reſts 235. And thus I affirme, that 49 is the neareſt cubick rot in whole numbers of 117884, as here by the work you may ſee.

```
  00
  53 (2(3 (5
 117884(49
 ------
  64
   12
   48
 ------
  432
  972
 ------
  729
 ------
 53649.
```

Now to finde a denominator for the 235 remaining, I ſquare the rot 49, ſo ariſeth 2401. Then I triple the ſaid ſquared number, and there ariſeth 7203; and then I triple the rot 49, ariſeth 147, to which I adde one, and it makes 148. All which ſummes ioyned together, make 7351, and ſo the true cubick rot of 117884 is 49 and $\frac{235}{7351}$ parts of an unite.

Theoremes ſhewing the true proportion that a bullet of one mettall beareth to the like bullet of a contrary metall, as alſo the proportion that the circumference of any bullet or globe &c. beareth to the diameter, and of the ſuperficiall content thereof to the diametrall ſquare thereof, the which according to Archimedes are thus proved.

All circles are equall to that right angled triangle, whoſe containing ſides, the one is equall to the ſemidiameter, the other to the circumference thereof.

The proportion of all circles to the ſquare of their Diameter, is as 11 to 14.

All globes beare together triple that proportion that their Diameters doe.

The

The circumference of any circle, is more nor the triple of his Diameter, by such proportion as is lesse then $\frac{1}{7}$ and more nor $\frac{10}{71}$

A bullet of iron, to the like bullet of marble stone, is in proportion as 15 to 34.

A bullet of lead to the like bullet of iron, is in proportion as 28 is to 19.

A bullet of lead to the like bullet of marble stone, is in proportion as 4 to 1.

The Diameter of any bullet &c. is in proportion to the circumference as 7 to 22.

How by knowing the true weight of any one bullet, and the diameter of the peece due for the said bullet, to finde out the weight of any other bullet belonging to a contrary peece of Ordnance.

Question.

Admit a Demy Cannon of 7 inches Diameter shot an iron bullet of 32 pound weight, I demand what weight shall that bullet be of, that serves a Cannon of 9 inches diameter?

Resolution.

To answer this and such like, there is a generall rule; for Euclid in his sixth Book of geometricall elements, hath demonstrated and proved, that all globes are in triple proportion to their Diameters; therefore I multiply the proportion of each bullet cubically, and I finde the cube of 7 is 343. and the cube of 9 is 729. Then by the rule of proportion I say, if 343 yeld 32 pound weight, what shall that bullet weigh whose cube is 729? So multiplying 729 by 32 pound, the weight of the lesser bullet, ariseth 23328, which divided by the 343, being the cube of the lesser bullet, yeldes in the quotient 68 pound and $\frac{4}{7}$ parts of a pound, so much shall that bullet weigh that serves a Cannon of 9 inches diameter, as by working the rule you shall find.

Another easie conclusion, how by the weight of a small bullet known, to find out the weight of a greater.

Question.

A bullet of 3 inches diameter weighing foure pound weight, what shall a bullet of the same metall weigh whose diameter is twice the heigth of the former (that is 6 inches high?)

Resolution.

I work in the order of the former conclusion, multiplying the diameter of each bullet cubically, and dividing, as afore is shewed, the quotient is 32 pound weight, so much shall the greater bullet weigh.

Example

Example.

In the last conclusion the weight of the greater bullet weighed 32 pound, being 6 inches diameter, how shall I finde the weigt of a bullet of the same metall that is but halfe that heigth.

Resolution.

I finde the cube of 6 is 216, and the cube of 3 is 27, so framing the converse rule of 3, I say, if 216 yeld 32 pound weight, what will 27? And multiplying 27 by 32, and dividing the product by 216, the quotient yelds 4 pound, the true weight of the lesser bullet. And note that if you know the diameter and weight of any bullet, and would know the weight of one that is but $\frac{1}{2}$ the heigth of the first, the lesser shall be in weight but the $\frac{1}{8}$ part of the greater. Or knowing the weight of any bullet, if you would know the weight of another of the same metall, being twice the heigth of the former, the greater shall weigh 8 times as much as the lesser, as in a figure demonstratively hereafter drawne you may see.

How by knowing the weight of any bullet whose diameter containeth both whole inches, and parts of whole, how you should work to finde out the true weight of another whose diameter ends with a fraction.

Question.

If a Sakeret shot a bullet of 2 inches $\frac{3}{4}$ diameter, of 3 pound weight, what shall a Culvering shot weigh of 5 inches $\frac{1}{4}$ diameter?

Resolution.

To answer this or such like, I reduce each bullet into his proper fraction, and I finde that the bullet of 2 inches $\frac{3}{4}$ diameter will be in a fraction $\frac{11}{4}$ or 11 quarters, and the Culvering bullet of 5 inches $\frac{1}{4}$ heigth will be $\frac{21}{4}$ then I multiply each of these 2 fractions cubically, and I finde that the cube fraction of the lesser bullet is $\frac{1331}{4}$ and the cubick fraction of the greater is $\frac{9261}{4}$ which knowne, I set downe under three pound (the weight of the lesser bullet) the unite 1, and it will represent a fraction thus $\frac{1}{4}$, and then multiplying and dividing by the golden rule in fractions, I find that the weight of the Culvering shot of 5 inches $\frac{1}{4}$ diameter will weigh 20 pound weight and almost $\frac{1}{4}$ pound, as in the working you may finde.

How

How by knowing the diameter and weight of an iron bullet, to finde the weight of a bullet of marble ſtone of the like diameter; or how by knowing the weight and heigth of a bullet of marble, to find out the weight of an iron bullet of like heigth.

Queſtion.

Admit an iron bullet of 4 inches heigth weigh 9 pound, I demand what ſhall a bullet of marble ſtone weigh of like diameter?

Reſolution.

In a Theoreme afore mentioned, I finde that a bullet of iron to the like bullet of marble ſtone, ſhall beare ſuch proportion as 34 is to 15. And therefore I multiply the weight of the iron bullet knowne, being 9 pound by 15, (the proportion the ſtone bullet beareth thereto) ſo ariſeth 135, which divided by 34, the quotient is 3 pound, and $\frac{33}{34}$ parts of a pound; that is, 4 pound wanting $\frac{1}{34}$ part of a pound, ſo much ſhall the bullet of marble ſtone weigh that is in diameter and circumference equall to the like bullet of iron. In like order reducing the weight of the ſtone bullet into his proper fraction, you ſhall have $\frac{135}{34}$ pound, which divided by 15, the proportion the ſtone bullet beareth to the like bullet of iron, your quotient is 9, the number of pounds that the iron bullet weigheth.

How by knowing the heigth and weight of an iron bullet, to finde out the weight and heigth of the like bullet of lead. or how to finde the weight of an iron bullet, by knowing the weight of a leaden bullet of like diameter.

Queſtion.

There is a Cannon that ſhoots an iron bullet of 72 pound weight, what ſhall a bullet of lead of the ſame diameter weigh?

Reſolution.

To work this, I note that the theoreme before ſaith, that a bullet of iron to the like bullet of lead, ſhall beare ſuch proportion as 28 is to 19, therefore I multiply 72 (the pounds which the iron ſhot weigheth) by 28, ſo ariſeth 2016, which divided by 19, the quotient is 106 pound $\frac{2}{19}$, ſo much will a leaden bullet weigh that is proportionall to an iron bullet of 72 pound weight.

In this order by working, as I have ſhewed in the end of the laſt concluſion, you may, by knowing the weight of the leaden bullet, finde out the weight of the like bullet of iron.

How you may finde out the weight of any ſtone bullet of marble, by knowing the weight of the like bullet of lead, or how by knowing the weight of the ſtone buller, to finde out the weight of a leaden bullet of like proportion.

Queſtion.

If a bullet of lead weigh 106 pound, what ſhall a bullet of marble ſtone weigh of the ſelfe like proportion?

Reſolution.

To anſwer this, I finde that a bullet of lead to the like bullet of marble, beareth ſuch proportion as 4 to 1. Therefore multiplying 106 by 1, and dividing the product by 4, the quotient will be 26 pound and ¼ ſhewing the true weight of a ſtone bullet, that is proportionall to the like bullet of lead.

And now to finde out the weight of the leaden ſhot, by knowing the weight of the ſtone ſhot, reduce the ſtone bullet into his proper fraction, you ſhall have ¼, and ſetting 1 under 4 fraction wiſe, multiply the numerators together, and likewiſe the denominators, and dividing the product a ſing of the numerators by the product of the denominators, your quotient will be 106 pound, ſhewing the true weight of the leaden bullet.

If you have or doe know the weight and true heigth of a bullet of ſtone, or any other metall, and are deſirous to know the weight and heigth of another bullet that is greater or leſſer, and of the ſame metall, in working as the firſt concluſion ſheweth, you ſhall have your deſire.

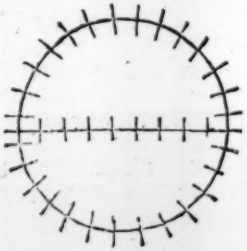
To finde out the circumference of any circle or bullet.

Queſtion.

I demand how many inches is about the circumference of that bullet whoſe diameter is 9 inches?

Reſolution.

To work this, or any ſuch like, there is a generall rule, as thus, that the proportion of the diameter to the circumference is as 7 to 22, therfore multiplying the diameter 9 by 22, ariſeth 198, which ſumme divided by 7, the quotient is 28 ⅐ ſhewing the true number of inches about the circumference of a bullet of 9 inches diameter, as the figure here demonſtrated ſheweth.



How you may by knowing the circumference of any bullet, finde out the heigth or diameter of the ſame

Queſtion

The circumference of the bullet in the laſt concluſion contained 28 inches ⅐ as in the demonſtration you may ſee: I would know how I ſhould work to finde how many inches the diameter of the ſame is?

Reſolution.

To anſwer this and all ſuch like, I muſt work contrary to the former concluſion, firſt reducing the whole number and broken being 28 inches ⅐ into his proper fraction, and it will be $\frac{197}{7}$ then multiplying by 7, according to Archimedes doctrine, and dividing by 22, the quotient will be 9, ſo many inches is the diameter of the ſame bullet.

In this order you may finde out the diameter and circumference of all other bullets.

How to finde out the ſolid content of any bullet, &c.

Queſtion.

There is a bullet of iron, whoſe diameter containeth 9 inches, how many ſquare inches is in the ſolid content thereof?

Reſolution.

To know this and all ſuch like, there is a generall rule, as thus, to multiply the diameter in his ſquare, I meane cubically, and then multiply that product by 11, divide the totall ſumme by 21, the quotient sheweth the number of ſquare inches in that ſphericall globe or bullet, for 9 multiplied cubically ariſeth 729, which augmented in 11 is 8019, that totall divided by 21, yeelds 381 inches, and $\frac{3}{7}$, ſo many ſquare inches of iron will be in a bullet of 9 inches diameter.

To finde the true content of the ſuperficies of any circle drawn upon a flat, as on a table or paper, &c.

Queſtion.

There is a circle whoſe diameter is 21 inches, I demand how many ſquare inches are contained within the circumference of the ſame?

Reſolution.

To reſolve this or ſuch like, there is a generall rule, in taking ⅐ the diameter, and multiplying it in ⅐ the circumference, or ſquaring the diameter, and multiplying the product by 11, and dividing the reſult by 14, the quotient sheweth the Area or content of all the ſuperficies within the circumference thereof.

Example.

The ſquare of 21 is 441, which multiplied by 11 is 4851, that divided

by 14, yeeldeth in the quotient 346 inches $\frac{1}{2}$. Or other wayes, take the halfe of 21 inches, that is, 10 inches $\frac{1}{2}$, and take $\frac{1}{7}$ of the circumference, which is 33 inches, reduce them into fractions according to the rule, you have $\frac{21}{2}$ for the diameter, and $\frac{33}{1}$ for the circumference, then multiplying the one by the other, the product is $\frac{1386}{4}$, which divided by the denominator 2, yeeldeth in the quotient $346\frac{1}{2}$ as before. In this order you may finde out the content of the plaine of any circle.

To finde out the circumference of any bullet or globe divers and sundry wayes.

Question.

How many inches is about the circumference of that bullet or globe, whose diameter is supposed to be 21 inches high?

Resolution.

After you have with your callaper compasses found out the heigth of the diameter, multiply the same by 22, so there will arise 462, the which divided by 7, the quotient will be 66 inches, the true measure of the circumference.

Another way.

Triple your diameter, and thereto adde the $\frac{1}{7}$ part of the same, your product is the circumference.

Example.

The triple of 21 is 63, and the $\frac{1}{7}$ part of 21 is 3, which added to 63, is 66 inches, as before.

Another way to work the same.

Look how many times you can have 7 in the diameter, so many times must you have 22 in the circumference. Example. The diameter being 21 inches, divided by 7, yeelds in the quotient 3, by which if you multiply 22, your product will be 66 inches, for the circumference, as before. In this order you may finde out the circumference of any bullet, or spherical body, &c.

To finde out the superficies of any round body, as bullet, globe, &c. divers and sundry wayes.

Question.

I have a demy Cannon bullet of 7 inches diameter, I demand how many inches the superficiall content thereof is?

Resolution.

To answer this and all such like, I must in the order before shewed, finde out the circumference of the bullet, and I finde that a bullet of 7 inches diameter shall containe 22 inches in circumference, which circumference being multiplied in the diameter, ariseth 154 inches, the true number of inches contained upon the superficies of a bullet of 7 inches diameter.

Another

Another way.

Multiply the square of the diameter of any bullet or globe by $\frac{11}{7}$ the product is your desire. Example, The bullet whose diameter was 7 inches being squared, the square thereof is 49, which multiplied by 22, yields 1078, which summe divided by 7, the quotient is 154 inches, as before.

Another way.

Divide the square of the circumference of any bullet by $\frac{11}{7}$ your quotient numbers will shew you the superficiall measure of the same.

Example.

The circumference of the bullet aforenamed of 7 inches diameter containeth 22 inches, the square thereof is 484 inches, that number divided by $\frac{11}{7}$ as you doe in fractions, in setting an unite under the square number thus, $\frac{484}{1}$ and multiplying the said square number by the denominator of the other fraction being 7, ariseth 3388, which divided by the numerator 22, the quotient is 154 inches, the superficiall content thereof, as before.

How you may finde out the solid content or crassitude of any round bullet or globe, &c. divers wayes.

Question.

In the question before propounded of the bullet, whose diameter was 21 inches, I would know how many inches is in all the solid or massive content thereof?

Resolution.

I multiply the diameter cubickly, and after multiplieth that cubick number by 11, so ariseth 101871, the which divided by 21, my quotient is 4851, shewing there is so many inches in the solid content of a bullet or globe of 21 inches diameter.

Another way.

Multiply the cube of $\frac{1}{3}$ the circumference by 49, and divide the product arising thereof, by 363, your quotient will shew your desire. Example: The circumference of a bullet whose diameter is 21 inches, containeth 66 inches, the $\frac{1}{3}$ thereof is 33 inches, the cube whereof is 35937, that summe multiplied by 49 is 1760913, which divided by 363, the quotient is 4851 inches as before.

How you may by knowing the diameter and weight of any bullet, or other round body, finde out the diameter of any bullet or globe that weigheth twice the weight of the former.

Question.

There is a demy Culvering bullet of 4 inches diameter weighing 9 pound, I demand the true weigth of that bullet which weigheth 18 pound weight.

Resolution.

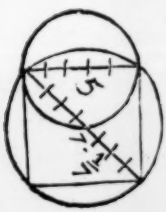
To work this and all such like demands, this rule is generall in multiplying the heigth of the lesser bullet whose weight is knowne cubically, then doubling that summe, and extracting the cubick root thereof, the quotient will answer your question.

Example.

The bullet afore named of 4 inches diameter, being multiplied cubically is 64, that summe doubled is 128, the cubick root thereof is 5 inches, and a fraction remaining scarce the $\frac{1}{4}$ part of an inch, shewing the true heigth of a bullet that weigeth 18 pound. In this order if you have a bullet that is 3 times as heavy as another of like metall, whose weight is knowne, and that you desire to know the diameter of the greater bullet; in tripling the cubick number of the lesser bullet whose diameter is knowne, and extracting the cubick root thereof, you shall finde out the true heigth of the greater bullet. Or if you would finde out the heigth of any bullet of like metall, that weigheth 4 times as much as another bullet whose weight is knowne, quatriple the cubick number of the diameter of the lesser bullet, and extract the cubick root thereof, your quotient will satisfie you. Or if 5 or 6 times &c. in working as I have shewed, you may finde your request.

How you may Geometrically finde out the diameter of any bullet that weigheth twice as much as another knowne bullet.

Take the true heigth or diameter of the lesser bullet whose weight you know, and square the same as you see in the figure following. Then draw a line that may divide the said square in 2 equall parts, in the 2 opposite angles, and that line shall be the diameter of a bullet twice the weight of the other: then divide that diametriall line in 2 equall parts, setting one foot of your compasse in the center or midst thereof, and with the other foot draw a circle, and that circumference will represent the proportion of a bullet twice as much in weight as the lesser.

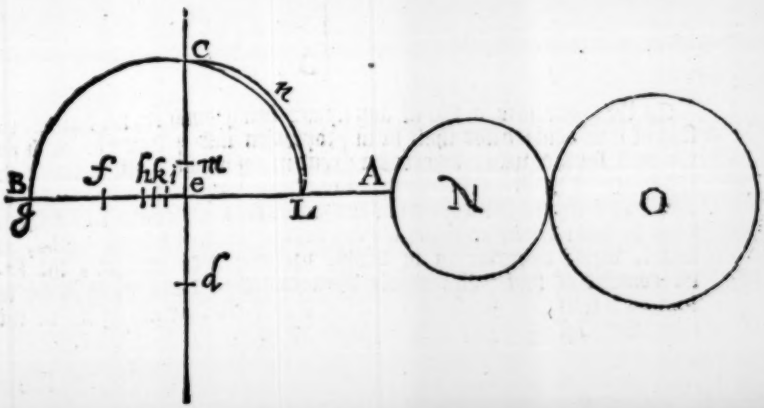


How you may Arithmetically prove this concluſion.

The diameter of the leſſer bullet is 5 inches, the ſquare of it is 25, that ſumme double is 50, the ſquare root of 50 is 7 $\frac{1}{7}$ and ſo much is the diameter of the greater bullet, as in the figure here drawne you may ſee.

Another way Geometrically to finde the diameter of any unknowne bullet that is double the weight of a knowne bullet.

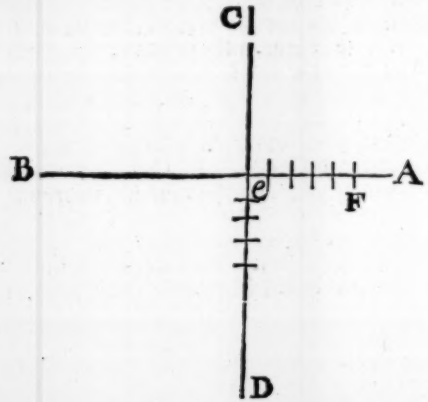
Draw a ſtraight line of what length you think good, as you ſee the line A. B. then draw another croſſe line perpendicular to the ground line as you ſee the line C. D. note the meeting or croſſing of the lines, as is the point E. This done, open your compaſſe the iuſt length of the diameter of the leſſer bullet whoſe weight you would double, ſetting one foot of the compaſſe in E. and the other in D. and meaſure towards B. twice that diameter, as is done in the points F. G. Then divide the line E. F. in 2 equall parts in the point H. and after divide the line E. H in 2 equall halfes, as in the point I. And laſtly divide the line I. H. in 2 equall parts in the point K. Which done, open your compaſſe, placing one foot in K. and the other in G. draw $\frac{1}{2}$ a circle, as you ſee, I doe the ſemicircle L. C. G. After divide the line C. D. in 2 equall parts in the point M. and opening your compaſſe the iuſt wideneſſe of one of thoſe parts, ſet one foot in M. and with the other foot draw the line C. N L. Which done, the bullet whoſe diameter is the line L. E. will weigh twice as much as the bullet whoſe diameter is the line E. D. as Euclid in his 6 book of Geometricall Elements doth demonſtrate and prove.



The greater circle O. doth shew the proportion of a bullet that weigheth twice as much as the lesser circle N. both the said bullets being cast of one like metall.

Another demonstration to prove the former conclusion by numbers.

In a conclusion before set downe, where the bullet of a demy Culverting of 4 inches diameter weighed 9 pound, I proved that a bullet whose weight was 18 pound should be more then 5 inches diameter. Even so I have hereunder divided the line E. D. of the former conclusion, being supposed to be the diameter of a bullet whose weight is knowne, into 4 equall parts or inches. And likewise dividing the diameter F. E. into the like divisions, it containeth 5 of those parts, and almost the $\frac{1}{10}$ part of an inch more, shewing the true heigth of a bullet that is twice as much in weight as the lesser bullet of 4 inches diameter, as this figure sheweth.



As the upper face or side of any square being doubled, the square arising of that doubled side shall be in proportion just 4 times as much as the first square was; whereas a great many would think it would be but twice as much. Even so the diameter of any circle being doubled, the Area or superficiall content of the flat of the same circle so doubled, shall be foure times as much as the other. Also any cube, globe, or bullet, whose diameter is in double proportion to another, the solid content of that bullet whose diameter is so doubled, shall be in weight 8 times as much as the lesser, as these two examples in the conclusions following figuratively drawne shew.

How

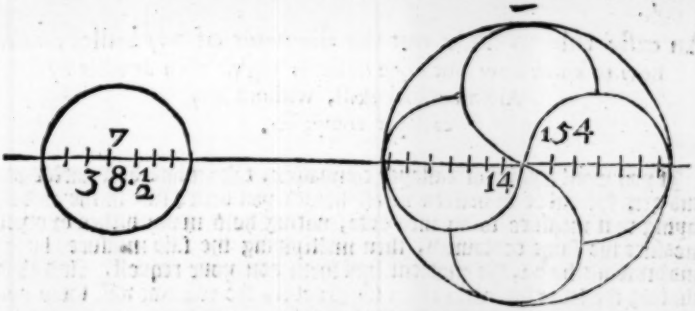
How by knowing the ſuperficiall content of the plaine of any circle, to finde out the ſuperficiall content of another that is twice the diameter of the firſt.

Queſtion.

There are two circles drawne, the one 7 inches diameter, the other 14 inches: how much is the content of the greater circle more then the leſſer?

Reſolution.

To anſwer this or the like, by the theoremes afore mentioned, I ſquare the diameter of the leſſer circle being ſeven inches, ſo ariſeth 49 inches,



that ſquare multiplied by 11, yelds 539, the which divided by 14, the quotient is 38 inches ½ ſhewing the ſuperficiall content of the circle of 7 inches diameter. Alſo working in the ſame order, I finde the content of the greater circle of 14 inches diameter to containe 154 inches, which divided by 38 ½ the quotient is 4, ſhewing that the ſuperficiall content of the greater circle is juſt 4 times as much as the leſſer.

By knowing the weight and heigth of any one bullet, to finde out the weight of another of twice the heigth of the former.

Queſtion.

If a bullet of 4 inches diameter weigh 9 pound, how much ſhall a bullet of 8 inches heigth weigh?

Reſolution.

To know this or the like, multiply the diameter of each bullet cubically, and I finde the cube of 4 is 64, and the cube of 8 is 512; which knowne, I frame the rule of proportion, ſaying, if 64 yeld 9 pound, what will 512? and in multiplying and dividing according to the rule, my quotient is 72 pound, the weight of the greater bullet, (that is

iuſt 8 times the weight of the leſſer bullet.) For further proofe behold theſe 2 figures in cubick forme, where you may ſée that the greater figure whoſe ſide is in double proportion to the leſſer, doth containe 8 times the quantity of the leſſer.

An eaſie rule to finde out the diameter of any bullet, and how to know how much one bullet is higher then another by Arithmeticall skill, without any callaper compaſſes.

If you want a paire of callaper compaſſes, take a line or a garter &c. and gird the bullet or bullets whoſe heigth you deſire iuſt in the midſt, laying that meaſure to an inch rule, noting how many inches or other meaſure the ſame containeth, then multiplying the ſaid meaſures by 7, and dividing by 22, the quotient will ſhew you your requeſt. And then abating the leſſer diameter from the greater, the remaine will ſhew you how much the one is higher then the other.

Example.

Suppoſe the circumference of the one bullet be 16 inches, and the circumference of the other 26 inches, in working as above is taught, I finde the diameter of the leſſer bullet is 5 inches $\frac{4}{11}$ and the diameter of the greater bullet 8 inches $\frac{4}{11}$, ſo abating the leſſer from the greater, the remaine is 3 inches and $\frac{0}{11}$ parts of an inch, ſhewing the greater bullet is ſo much in heigth more then the leſſer. The like is to be obſerved with any other.

By this rule you may know how much the circumference or any part of your peece is higher then another.

A Table shewing the weight of all iron bullets, from the Fawconet to the Cannon, in Habberdepoiz weight.

Heigth of the shot in inches and parts of inches.	Weight of the shot in pounds and parts of pounds.	Heigth of the shot in inches and parts of inches.	Weight of the shot in pounds and parts of pounds.
Heigth.	Weight.	Heigth	Weight.
2.	1. 3/7	5. 1/4	19. 3/7
2. 1/4	1. 1/4	5. 1/2	22. 1/7
2. 1/2	2. 1/7	5. 3/4	25. 5/6
2. 3/4	3. 1/7	6.	29. 1/7
3.	4. 1/2	6. 1/4	32 1/2
3. 1/4	5.	6. 1/2	36. 5/7
3. 1/2	6. 2/7	6. 3/4	40. 3/4
3. 3/4	7. 6/7	7.	46.
4.	9.	7. 1/4	52. 6/7
4. 1/2	10. 1/2	7. 1/2	56. 5/8
4 1/2	12. 3/7	7. 3/4	64. 1/2
4. 1/4	14. 5/8	8.	70.
5.	16. 1/4	8. 1/4	76. 3/7

How you may Arithmetically know the true breadth of the plate of the ladle that is due for any peece of Ordnance, by knowing the heigth of the bullet fit for the said peece.

Take a line and compasse the bullet in the midst, laying the same measure to an inch rule, divide the same measure into five equall parts, three of those parts is the iust breadth you ought to make your plate of, which being orderly placed on the staffe, and bent circularly, serves to hold the powder in: the other 2/7 parts being cut and taken away, and so left open, serves to turn the powder into the peece, the which to do Gunner like, as soon as you have filled the ladle so full that you may strike the same with a rule, and put the same into the mouth of the peece, fit your thombe upon the upper part of the staffe, towards the end next the tampion or head

thereof, and so thrusting the ladle gently home to the breech of the peece, turne the rammer staffe, so as your thombe fall directly under the staffe, and so shall you empty your ladle orderly.

How to know the $\frac{5}{7}$ parts of the bullets circumference, that you may make the plate of your ladle orderly, and of that iust breadth, lay the measure of the whole circumference to an inch rule, and then multiply the same by 5, and divide the product by the denominator 5, your quotient will tell you truly the breadth that the plate of your ladle ought to be of.

Example.

A Cannon whose bullet is 7 inches high, will be 22 inches in the circumference, that multiplied by 5 is 66, which divided by 5, the quotient is 13 inches $\frac{1}{5}$ the true breadth that the plate for a Cannon ladle of 7 inches diameter ought to be of.

The length of the ladle is to be made according to the length, heigth, and weight of the peece for which it is made, which in a Table in the end of the book you may finde set downe for all sorts of peeces.

How to make a ladle for a chamber-bored peece.

Open your compasse the iust diameter of the chamber, within $\frac{1}{8}$ part of an inch thereof. Divide that measure in two equall parts, then set your compasse to one of those parts, and with the one foot fixed on a paper or smooth board, draw with the other foot a circle, the diameter thereof will be a iust quarter of an inch shorter then the diameter of the chamber bore, by the circumference whereof, you may finde out the true breadth of the plate of a ladle that is fit for such a chamber-bored Cannon, by the rule afore set downe how to finde the true breadth of the plate of any ladle for any other peece of Ordnance, in taking the $\frac{5}{7}$ parts of the circumference thereof, the length ought to be twice the diameter and $\frac{1}{7}$ parts, to hold at two times the iust quantity of corne powder that is due to charge such a chamber-bored Cannon with.

Example.

The diameter of the circle drawne for any Cannon whose chamber-bore is 7 inches, containeth 6 inches $\frac{3}{4}$, the circumference whereof is 21 inches $\frac{5}{8}$, the $\frac{5}{7}$ parts thereof is 12 inches $\frac{1}{4}$, and so much ought that ladle to be in breadth, and in length it out to be 18 inches $\frac{1}{2}$. In this order you may work to make a ladle in length and breadth for any bel-bored Cannon: and to finde out the thicknesse of the metall at the touch-hole, or the heigth of the bore thereof, the conclusion following will shew you.

How

How to finde out the heigth or diameter of the chamber, in any chamber-bored Cannon, or other peece of Ordnance, and how to finde out the thickneſſe of the metall round about the chamber thereof.

Take your priming iron, or elſe a ſtraight peece of wyer, and bow the end thereof in manner of a hook, and then put the ſame into the touch-hole, down to the loweſt part of the concavity of the peece, and then with your knife, or elſe with a peece of chalk, make a ſtroke upon the wyer hard by the upper part of the metall, without the peece at the touch-hole, then meaſure by your inch rule, how long the wyer is from that ſtroke to the end. After put in the ſame wyer againe, and pull it up, ſo as the bowed end may reſt or ſtay within the cilinder or concave of the peece: and make another mark or ſtroke on the ſaid wyer, hard by the upper part of the metall, the diſtance betweene thoſe two ſtrokes, is the iuſt thickneſſe of the metall round about the chamber, the which abated from the length of the wyer (I meane from the firſt ſtroke to the loweſt end) the remaine is the true diameter of the chamber-boze in that peece.

Example.

Admit the length of the wyer from the end of the concavity to the firſt ſtroke containeth 15 inches, and the diſtance betweene the 2 ſtrokes is 8 inches: then thoſe 8 inches is the iuſt thickneſſe of the metall about the chamber; which abated from 15 inches, reſts 7 inches, the iuſt diameter of the chamber in ſuch a peece.

By Arithmetick skill, how to know whether the carriage for your peece be truly made or no: or how the carriage for any other peece of Ordnance ought to be made.

Meaſure the iuſt length of the cilinder or boze of your peece, the planks of your carriage ought to be once and a halfe that length. Alſo meaſure the diameter of the peece, and the ſaid planks at the foze end ſhould be in depth 4 times the diameter, and in the midſt 3 times and ½ the diameter, and at the end nert the ground, two times and ½ the diameter, and in thickneſſe once the diameter.

Example.

Admit a Culbering of 6 inches diameter is in length in the boze thereof 20 times that meaſure (that is 10 foot long) then I ſay that the planks of her carriage ought to bo 15 foot in length; and at the foze end nert the peece 2 foot in bzeadth, and in the midſt one foot thzee quarters, and at the loweſt end nert the ground one foot and a quarter, and in thickneſſe halfe a foot. Alſo every carriage ought to have foure tranſomes, and ought to be ſtrengthened with ſtrong iron bolts.

The holes or centers wherein the trunions ought to lie, ought to be three times and $\frac{1}{3}$ the diameter from the fore end of the carriage, and in depth $\frac{2}{3}$ parts of the thickneſſe of the trunions, which depth you may eaſily finde out, as thus: take the heigth or diameter of the trunions, and multiply the ſame meaſure by 2, and dividing by the denominator 3, the quotient will ſhew your deſire.

How by knowing the weight of any one peece of Ordnance, to finde out the weight of any other.

Queſtion.

If a Saker of foure inches diameter weigh 1600 pound weight, what will a Culvering weigh that is ſix inches diameter?

Reſolution.

Some would think that the rule of proportion plainly wrought, would anſwer this queſtion: but in that they are deceived; for the content of ſolid bodies being maſſie, are Sphericall or Cubicall in proportion, therefore you muſt multiply the diameters of every peece cubically, and ſet downe the weight of the peece knowne in the middle number, and ſo working according to the rule of proportion, you ſhall finde out the true weight of the greater peece.

Example.

4 inches the diameter of the leſſer peece, multiplied cubically, ariſeth 64 inches. Likewiſe the cubick number of the diameter of a Culvering of 6 inches high, is 216 inches; then framing the rule of proportion, I ſay, if 64 being the cube of 4 yeeld 1600 pound weight, (being the weight of a Saker of 4 inches bore) what will 216 being the cubick number of 6 inches, ſo multiplying 216 by 1600, ariſeth 345600, which divided by 64, yeelds in the quotient 5400 pound weight, ſo much weigheth the Culvering of 6 inches diameter,

In working by the converſe rule of proportion, you may not only prove this concluſion, but alſo may finde out the weight of any leſſer peece of Ordnance, by knowing the weight of a greater.

Example.

If 216 being the cube of 6 inches, yeeld 5400 pound in weight, what will 64 being the cube of 4 inches? ſo multiplying 5400 by 64, there ariſeth 345600, which divided by 216, the quotient is 1600 pound weight, ſhewing the true weight of the Saker of 4 inches diameter, as before.

Or if the diameters of the peeces whoſe weight you would know, containe both whole numbers and broken, in reducing each diameter into his proper fraction, and multiplying the ſame cubically, ſetting downe the weight of the peece knowne in the middle place, for the ſecond number, and multiplying and dividing as afore is taught, the quotient will ſhew you your requeſt, as the concluſion following will teach you.

Queſtion

Queſtion.

If a demy Culvering of 5 inches $\frac{1}{4}$ diameter weigh 2600 pound weight, what will a Cannon of 7 inches $\frac{1}{4}$ diameter?

Reſolution.

I reduce the diameter of each peece into his proper fraction, and I finde that the broken number of 5 inches $\frac{1}{4}$ diameter containeth $\frac{21}{4}$, which multiplied cubically, ariſeth $\frac{9261}{64}$. Likewiſe I reduce the diameter of the Cannon, being 7 inches $\frac{1}{4}$ into his fraction, and it is $\frac{29}{4}$, whoſe cube is $\frac{29791}{64}$: then I ſet an unite 1 under 2600, and it doth repreſent a fraction thus $\frac{2600}{1}$. Now to finde out the weight of the greater peece, I ſet downe theſe 3 new made fractions in the order of whole numbers, and working by the rule of proportion, I finde the greater peece weigheth 8363 pound, and almoſt $\frac{1}{2}$ of a pound: for in multiplying 29791 by 2600, there ariſeth 77456600, the which augmented by the denominator 4, maketh 309826400 for the dividend or number to be divided. Likewiſe the fraction of the leſſer peece being 9261, multiplied by his denominator 4, makes 37044 for a deviſor, which dividend being divided by the deviſor, yeeldeth in the quotient 8363 pound, and certaine parts of a pound, ſo much will a Cannon of 7 inches $\frac{1}{4}$ weigh being proportionall in metall to the other peece.

How you may by Arithmeticall skill, know how much of every kinde of metall any braſſe peece of Ordnance containeth.

Queſtion.

Every Gun-founder doth commonly uſe for every 100 pound weight of copper, to put in 10 pound weight of lattin, and 8 pound weight of pure tinne: I demand how many pound weight of every of thoſe metalls is in a Culvering of 5600 pound weight?

Reſolution.

To anſwer this or all ſuch like, I ioyne all the ſeverall mixtures together, and they make 118 pound, which I reſerve for my deviſor. Then I multiply the weight of the peece by every mixture ſeverally, and there ariſeth of the 100 weight of copper, being the greateſt mixture, 560000, the which ſumme is to be divided by the deviſor common (to wit, 118 pound) and the quotient is 4745 pound and $\frac{50}{118}$ parts of a pound: ſo much copper is in the ſaid peece. Now to know how much lattin is in the ſame, I multiply the whole weight of the peece by 10, the ſecond mixture, and the product is 56000, which number divided by the deviſor common, the quotient is 474 pound $\frac{68}{118}$: ſo much lattin is in the ſame peece. And laſtly to know how much tinne was in the ſame peece, I multiply the weight of the peece by 8, ariſeth 44800, which divided

vided by the deviſor 118, the quotient is 379 $\frac{71}{118}$: and ſo much tinne was put into the ſaid peece.

Now to proove the work if it be truly wrought or not, I adde all the 3 quotients together, and becauſe they doe all make the true ſumme of the whole weight of the peece according to the propoſition, I affirme the ſame to be truly wrought.

The Gun-founders doe hold and affirme, that the lattin doth incorporate, and cauſeth the peece to be of a good colour, and the tinne doth ſtrengthen and binde the other mixtures.

How you may know how farre any peece of Artillery will convey her bullet at the beſt of the randon, by knowing the utmoſt range and point blank of another peece, and how to proove the ſame: by which rule you may know how farre any peece will reach at point blank and utmoſt range.

Queſtion.

If a Saker at point blank conbey her bullet 200 paces, and at the beſt of the randon ſhot 900 paces, what will that Cannon doe which at point blank ſhots 360 paces?

Reſolution.

To reſolve this or the like, I ſet downe the numbers proportionall according to the rule, multiplying 900 paces (the utmoſt randon of the Saker) by 360 paces, (the point blank of the Cannon) ſo ariſeth 324000, which divided by 200 the number of paces the Saker ſhots at point blank, the quotient is 1620. And ſo many paces will a Cannon ſhot at the beſt of the randon, that at point blank rangeth 360 paces, as by working you may finde, and by experience better underſtand.

You may proove this concluſion by the converſe rule of proportion, multiplying 900 the number of paces the Saker ſhots at the beſt of the randon, by 360, the paces that the Cannon ſhots at point blank; and dividing that product 1620 the number of paces the Cannon ſhots at the beſt of the randon, the quotient is 200, ſhewing the number of paces that the Saker ſhall ſhot at point blank. In this order you may work the like concluſion by any other peece of Artillery, and finde out the point blank and utmoſt range thereof.

To know how much a bullet of iron will our-flie a bullet of lead of the like diameter, being both diſcharged out of one peece with one like quantity in powder.

Queſtion.

If a bullet of lead of 24 pound weight, being ſhot out of a peece with

with ⅓ parts of the ſaid bullets weight in powder, range at point blank 240 paces, how farre will a bullet of iron of like heigth range, being diſcharged out of the ſaid peece at point blank with the like quantity of powder?

Reſolution.

The proportion betweene a bullet of iron and a bullet of lead of the ſame heigth, I have ſhewed by the theorems and concluſions afore ſet downe; by which I finde that a bullet of iron being of equall diameter to a leaden bullet of 24 pound weight, the ſaid iron bullet ſhall weigh 16 pound ⅔ parts. And for as much as the leaden bullet is ſhot with ⅓ parts in powder of his weight, that is, with 16 pound of powder, which is very neare the full weight of the iron bullet, I finde that the ſaid bullet of iron ſhall out-flie the leaden bullet ⅕ part of the levell range (that is) the iron bullet ſhall flie, being ſhot as afore at point blank, 320 paces, that is, 80 paces further then the leaden bullet ranged at point blank. But if the peece out of which the ſaid bullets were ſhot, had beene mounted at any number of degrees of randon, the range of the iron bullet would ſhorten ſomewhat of the ⅕ of the overplus of the ſaid range: ſo that if the peece were mounted to the beſt of the randon, the ſaid bullet of iron would not out-flie the leaden bullet, not the ⅕ part of the ſaid range.

By knowing how much powder is ſufficient to charge any one peece of Ordnance, to know how much of the ſame powder will charge any other peece of Ordnance.

Queſtion.

If a Saker of 4 inches diameter require 5 pound of corne powder for her due loading, how much of the ſame like powder will charge a Cannon of 7 inches diameter?

Reſolution.

The plaine rule of proportion cannot reſolve this concluſion, except you multiply every number cubically, and then the quotient will ſhew you your deſire.

Example.

The cube of 4 is 64, and the cube of 7 is 343, which multiplied by the weight of the charge of powder due to load the leſſer peece, ariſeth 1615, which divided by the cubick number of the diameter of the leſſer peece, yeelds in the quotient 25 pound and almoſt ½ part of a pound: ſo much corne powder muſt a Cannon of 7 inches diameter have to charge her with. And note, that for as much as now the ſhoting with Serpentine powder is not uſed, being of no great force, and the making of corne powder never better knowne, nor of more force then now it is made and daily uſed in ſhoting in great Ordnance; as alſo the great Ordnance now caſt, not ſo fully fortified with metall as they ought to be, being

made more nimble and lighter then in times past; therefore the experienced Gunners doe observe as a generall rule, to abate ¼ part of the ordinary charge of corne powder in all peeces above 6 inches bore.

How by knowing how much Serpentine powder will charge any peece of Ordnance, to know how much Corne powder will do the like: or contrariwise, by knowing how much Corne powder will charge any peece of Ordnance, to know how much Serpentine powder will serve.

Question.

I demand how much Corne powder will charge that Culvering that shots 24 pound of Serpentine powder at a shot?

Resolution.

You must note for a generall rule, that 2 parts of Corne powder will doe as much as 3 parts of Serpentine powder: so that the proportion betweene the quantities or charges of these powders, is as 2 to 3, therefore I multiply 24 by 2, ariseth 48, which divided by 3, my quotient is 16 pound: so much Corne powder will charge the said Culvering. Or if you know how much Corne powder will charge her, you may know how much Serpentine powder will serve, in multiplying 16 pound the due charge of Corne powder by 3, and dividing the product by 2, your quotient is 24, as before. In this order you may doe the like by any other peece. And note that her due charge of Corne powder will lesse hurt the peece, then of Serpentine powder; for if Serpentine powder be ramd any thing hard, it is long a fiering: And a little heat long continued (which the Serpentine powder will doe) dangereth the peece more then a great heat presently gone, which effect Corne powder works.

How by knowing how farre your peece will shoot with her due charge in powder and shot, how to give a neare estimate, how farre she will shoot with a charge more or lesse then her common charge.

Question.

Admit a Culvering shot a bullet of 18 pound weight 900 paces, being charged with ⅓ parts in powder of the bullets weight, I demand, how farre should the said peece shot that bullet, if she had beene charged with as much powder as the bullet weigheth?

Resolution.

By the rule of proportion I finde she should shot ⅓ part further then she did at first shot, being charged with ⅓ part of more powder, that is 1200 paces: yet it is knowne she will not drive the bullet full out the ⅓ part

of

of this range further, although she will come very neare it, and the reason is, because the bullet flieth in a circular proportion more or lesse, a part of the range, after the insensible straight line or motion of the bullet be past, according to the degrées of randon the peece is elevated at. Also the concave of the peece being filled up with the powder, wad, and bullet, further then it ought to be, is a hinderance to the range of the bullet in proportion, according to that little quantity of the concave which the overplus of powder and wad filleth up; which though it be but little in comparison of the whole concavity to the range, yet it is a great hinderance in the bullets range, for that the bullet being so much nearer to the mouth, is driven into the ayre before the powder be all fiered, and have effected his force thereon: so that giving the peece her bullets weight in Corne powder, she will shot much further not with an ordinary charge, but it will both put the peece in danger of breaking, and those that are neare thereto in danger of their lives, if the peece be not all the better fortified with metall.

How by knowing how much powder a few peeces of Ordnance have spent, being but a few times discharged, to know how much powder a greater number of the same peeces will spend to bee often discharged.

Question.

If 4 Cannons being twice discharged at any service, shot 240 pound of powder, how much powder will charge 5 Cannons to shot every one 6 shots?

Resolution.

Work by the double rule of proportion, saying, If 4 Cannons shot 240 pound of powder, what will five Cannons? your quotient will be 300 pound: then say againe, if 2 times discharging yeld 300 pound of powder, what 6 times? and your quotient being 900 pound weight, sheweth that so much powder is due to 5 Cannons, to shot every one 6 shots.

To know how much powder every Cannon spent in the former conclusion at one shot.

Question.

If 5 Cannons burne 900 pound weight of powder, being but 6 times discharged, how much powder did every one shot at one shot?

Resolution.

Multiply 4 the number of peces first propounded by 2, the times they were discharged, ariseth 8, by which divide 240 the number of pounds in powder spent, the quotient is 30 pound, and so much powder did every

Cannon fire at one ſhot. Or elſe you may multiply the other 5 Cannons by the times they were diſcharged, and dividing that product by the powder ſpent, you ſhall have 30 pound weight of powder in your quotient alſo.

How to know how much powder every little cask or firken ought to containe, and how many of thoſe casks make a Laſt of powder, and how many ſhots any quantity of powder will make for any peece of Ordnance.

Every little cask or firken being empty, ought to weigh 12 pound, and being filled ought to hold an hundred pound weight of powder: ſo that the full cask ought to containe 100 of Habberdepois weight, and 24 of thoſe casks or firkins filled makes a Laſt of powder.

Queſtion.

How many ſhots will one of thoſe casks filled with powder make to a Culvering that ſhots 15 pound weight of corne powder at one ſhot?

Reſolution.

Divide the 100 pounds of powder in each firken by 15, the quotient will ſhew you that 100 weight of powder will be 6 ſhots to a Culvering that burnes 15 pound of powder at a ſhot, and 10 pound to ſpare.

How by knowing how many ſhots a firken of powder will make for a Culvering, to know how many ſhots a Laſt of powder will make for a Cannon.

Queſtion.

If a firken of powder of one hundreth weight charge a Culvering 5 times, ſhoting 20 pound of powder at every ſhot, how many of thoſe ſhots will be in a Laſt of powder (containing 24 hundreth weight) to a Cannon that ſhots 30 pound of powder at every ſhot?

Reſolution.

Reduce 24 hundreth weight into pounds, you have 2400 pound, then ſay by the rule of 3 direct, If 100 pound weight of powder be but 5 ſhot, what will 2400? and you ſhall have in the quotient 120 ſhot, for the ſaid Culvering that ſhots 20 pound weight at one ſhot. And whereas the queſtion ſayes, the Cannon ſhoteth 30 pound of powder at a ſhot, you muſt frame the backer rule of 3, and ſay, if 20 beare proportion to 120, what will 30? ſo multiplying 20 by 120, and dividing by 30, the quotient is juſt 80: ſo many ſhots of powder will be in a Laſt for any Cannon that ſhots but 30 pound weight at a ſhot. The like is to be done with any other.

To

To know how many shots of powder will be in a Graund barrell for any peece of Artillery.

Question.

If an ordinary Culbering shot 15 pound weight of good corne powder at one shot, how many times will a Graund barrell full of powder serve to charge her, the said barrell holding 300 weight?

Resolution.

Divide 300 by 15, the quotient is 20, your desire: the proofe is easie; for multiplying 20 by 15, you have 300 the number first propounded: the like is to be done if you would know how many shots will be in a graund barrell, for any other peece of Ordnance, in dividing the pounds of powder contained in the said barrell by the number of pounds of powder due to charge the said peece.

To know Arithmetically what proportion of every receit is to be taken to make perfect good powder, what quantity soever you would make at a time.

Question.

The best ordinary corne powder made in these dayes, containeth 12 parts of Mr. 3 parts of Cole, and 2 parts of Sulphur. The order how to compound and make the same is not peculiar to this Treatise, being meere Arithmeticall, I demand how many pound weight of every sort is to be taken to make 1000 pound weight of powder?

Resolution.

Adde all the parts or pounds of the receits together, ariseth 17 pound for your devisor. Then frame the golden rule, saying, if a mixture of 17 pound weight of powder require 12 pound of the Salt-peter, what will 1000 pound weight? In multiplying and dividing according to the rule, the quotient will be 705 pound, and $\frac{5}{17}$ parts of a pound: so many pound of the Mr. is to be taken to make 1000 pound weight. Againe, say by the same rule, if that a mixture of 17 pound weight doe require 2 pound of Sulphur, what will 1000? your quotient will shew you that 117 pound and $\frac{11}{17}$ is to be taken. And lastly by the said rule, say, if a mixture of 17 pound take 3 pound of Cole, what will 1000 pound take? and your quotient will tell you that 176 pound and $\frac{14}{17}$ parts is to be taken. The which 3 quotient numbers being all added together, will be just 1000 pound weight, and so proves the work to be truly done.

And note that the goodnesse or badnesse of powder may be knowen divers wayes, as by the colour, the taste of the tongue, the quick burning &c. Also the brimston is that materiall substance that is most apt to kindle with any spark, the cole most fit to continue or maintain the flame, and the Mr. being resolved into a windy exhalation worketh the effect, as chiefe and principall of the three.

Before I frame these conclusions following, of the randon or range of the bullet, and the diversity thereof, it is requisite to make knowne to the Reader, how that divers have written, and some will daunt that by the range or flight of the bullet out of any one peece of Ordnance known, they will or can tell the utmost range of all other, thinking that the range of the bullet out of any one peece should be proportionall to the bullet and charge of powder out of any other peece. Also some doe affirme, that out of any one peece of Ordnance discharged with sundry quantities of powder, they can tell the utmost range of the bullets discharged; and their reason is, that the range of those bullets shall be proportionall to the weight of powder wherewith they were charged. And hereupon some have given out rules which are false and full of errours: for the diversity of proportions cannot by the plain rule of proportion be resolved, as they affirm: but this may they do; Out of any one peece of Ordnance charged with one and the same like charge in powder and bullet, finde by the rule of proportion, the neare difference or ranges of the bullets, the peece being mounted or dismounted at any degree of randon; or by knowing how many paces, yards, feet, or other measure any peece will reach at point blank, by knowing the point blank and utmost range of another peece of Ordnance, they may finde the furthest range of the first. Or contrariwise, by knowing the utmost range and point blank of one peece, and the utmost randon of another peece, they may finde out the the point blank of that other peece, as by the rules following shall bee proved.

And it is to be noted, that any peece of Ordnance being mounted to the best of the randon or highest degree of the quadrant, the mouth and hollow cilinder of the said peece, must be erected to 45 degrees, that is at the 6 point of the skale in the quadrant (as the most part of quadrants now are made:) but some peeces will shot as farre at the 5 point, or at 41, 42, or 43 degrees according as the wind is of calumnie; for if any peece be mounted higher then 45 degrees, she shall shot shorter in every degree about the $\frac{1}{44}$ part of her utmost range. And therefore to know how to work these conclusions, you must by an instrument Geometricall, or by some line of measure truly divided, measure the distance from the peece to the place where the shot first fell or grazed, noting how many pearches, paces, yards, or other measure that distance is; which knowne, divide that distance by the degrees in the best of the randon, being 45, your quotient will tell you how many paces, yards, feet, or other measure your peece will shot further or shorter in mounting or dismounting a degree: the which knowne, as I have said, by one truly measured, you may before you shot, know very neare how farre or short your peece will shot, at the raising or dismounting of any degree, allowing one and the selfe like proportions in charging, both with powder, bullet and wad.

How

How by Arithmetick skill you may know how with one and the selfe same like charge in powder and shot, how much farre or short any peece of Ordnance will shoot, in mounting or dismounting of any degree; whereby you may know how farre your peece will shoot at any degree of the randon, by knowing the distance she shoots at the utmost grade.

Question.

If a Cannon at her utmost randon (that is, at 45 degrées) carry the bullet 1440 paces from the peece, how farre shall the same peece shot being dismounted but one degrée?

Resolution.

To answer this or all such like, I set downe the numbers according to the rule of proportion, and multiplying and dividing accordingly, I finde she shall shoot short in dismounting a degrée, 32 paces, or 53 yards, or 160 foot, which subtracted from 1440, rests 1408 paces; so farre shall the Cannon shot in dismounting her one degrée of her furthest range. Or you may doe the like in framing the golden rule, saying; If 45 degrées range 1440 paces, what will one? and you shall have 32 paces in your quotient, as before.

How by knowing the distance to the mark, by the conclusion or rule before, you may know whether your peece will shoot short or over the mark; or you may know how farre it is from your platforme to any mark, within the reach of your peece, only by knowing the utmost range of your peece, and the degrees she is elevated at.

Question.

Admit the same Cannon in the former conclusion, which ranged at the best of the randon 1440 paces, having the like charge in powder, shot, and wad, is laid to shoot at a mark being mounted at 30 degrées, I demand how farre it is from the peece to the said mark, or how farre the said peece doth carry so mounted?

Resolution.

To answer this, I multiply the paces my peece reacheth at the best of the randon, by those degrées in the proposition (to wit) 30 degrées, and there ariseth 43200, which divided by 45, my quotient is 960 paces, (that is, 40 paces lesse then a mile) so farre will that peece shot being mounted at 30 degrées. And if you would know how much this is short of the utmost range, abate the same from the said range, the remaine is your desire. As 960 paces abated from 1440, rests 480 paces,

so

so much doth the shot short of her best randon. In this order by 2 shots knowne, you may know what any peece of Ordnance will doe, being mounted above 10 degrees to the best of the randon, but under 10 degrees you should erre something in this practise, because the range of the bullet lieth a great part of the way in an insensible straight line, and the peece mouth elevated above 10 degrees, shoots or drives the bullet in a more circular proportion.

The range or flight of the bullet by the draught in the next leafe may be understood. And note that in service there is no peece of Ordnance lightly mounted above 15 or 20 degrees, except morter peeces, and such like.

How to make a table of randons, or goe very neare to know the true range of the bullet out of all sorts of peeces, being mounted from degree to degree.

Many Authors have taught how to make a table of randons, whereas some of them never shot in any peece of Ordnance in their lives. And for as much as I finde their writing and reasons differing, I think it will be a very hard matter to make a perfect table of randons, except the same be tried and experimented with some peece of Ordance in some convenient ground. I never heard nor read of any that hath as yet fully put the same in practise, the which would be much available to every Gunner, to know what every peece would doe at the mount of every degree or point of the quadrant, the motion or range of the bullet being something veriable at the mount of every degree. You shall very neare finde out the true range or randon of the bullet shot out of any peece of Ordnence, the peece mounted at any degree of randon, as thus:

Charge your peece with her due loading, in powder, shot, and wad, laying the peece at point blank, which you may easily try by putting the rule of the quadrant into the peece mouth, and coyning the peece at the breech, so as the plummet may cut the quadrant in the line of levell, as you see in the first figure hereafter drawing, that peece lieth point blank: which done, give figure, and mark where the bullet first grazeth, after bring your peece to the same platforme, so as the wheeles and carriage stand neither higher nor lower then they did the first shot: and being charged with one and the selfe like quantity in powder, bullet, and wad as before, the peece being of like temper, raise her mouth one degree, as the second figure sheweth: discharge her, and mark where the pellet falleth or grazeth first; then measure how farre the first graze of the second bullet is beyond the graze of the first bullet, so much will the peece convey the bullet further at the mount of every degree, or very neare thereto. But being mounted above 20 degrees, she will shoot shorter and shorter, a little at the mount of every degree to the best of the randon, according to the brigty and circular motion of the bullet. If the peece be

mounted

so much doth the shot shoot of her best randon. In this order by 2 shots knowne, you may know what any peece of Ordnance will doe, being mounted above 10 degrees to the best of the randon, but under 10 degrees you should erre something in this practise, because the range of the bullet lieth a great part of the way in an insensible straight line, and the peece mouth elevated above 10 degrees, shoots or drives the bullet in a more circular proportion.

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How to make a table of randons, or goe very neare to know the true range of the bullet out of all sorts of peeces, being mounted from degree to degree.

Many Authors have taught how to make a table of randons, whereas some of them never shot in any peece of Ordnance in their lives. And for as much as I finde their writing and reasons differing, I think it will be a very hard matter to make a perfect table of randons, except the same be tried and experimented with some peece of Ordnance in some convenient ground. I never heard nor read of any that hath as yet fully put the same in practise, the which would be much available to every Gunner, to know what every peece would beare at the mount of every degree or point of the quadrant, the motion or range of the bullet being something verifiable at the mount of every degree. You shall very neare finde out the true range or randon of the bullet shot out of any peece of Ordnance, the peece mounted at any degree of randon, as this:

Charge your peece with her one loading, in powder, shot, and wad, laying the peece at point blank, which you may easily try by putting the rule of the quadrant into the peece mouth, and coyning the peece at the breech, so as the plummet may cut the quadrant in the line of levell, as you see in the first figure hereafter drawing, that peece lieth point blank: which done, give figure, and mark where the bullet first grazeth, after bring you peece to the same platforme, so as the wheeles and carriage stand neither higher nor lower then they did the first shot: and being charged with one and the selfe like quantity in powder, bullet, and wad as before, the peece being of like temper; raise her mouth one degree, as the second figure sheweth: discharge her, and mark where the pellet falleth or grazeth first; then measure how farre the first graze of the second bullet is beyond the graze of the first bullet, so much will the peece convey the bullet further at the mount of every degree, or very neare thereto. But being mounted above 20 degrees, she will shoot shorter and shorter, a little at the mount of every degree to the best of the randon, according to the heighy and circular motion of the bullet. If the peece be

mounted

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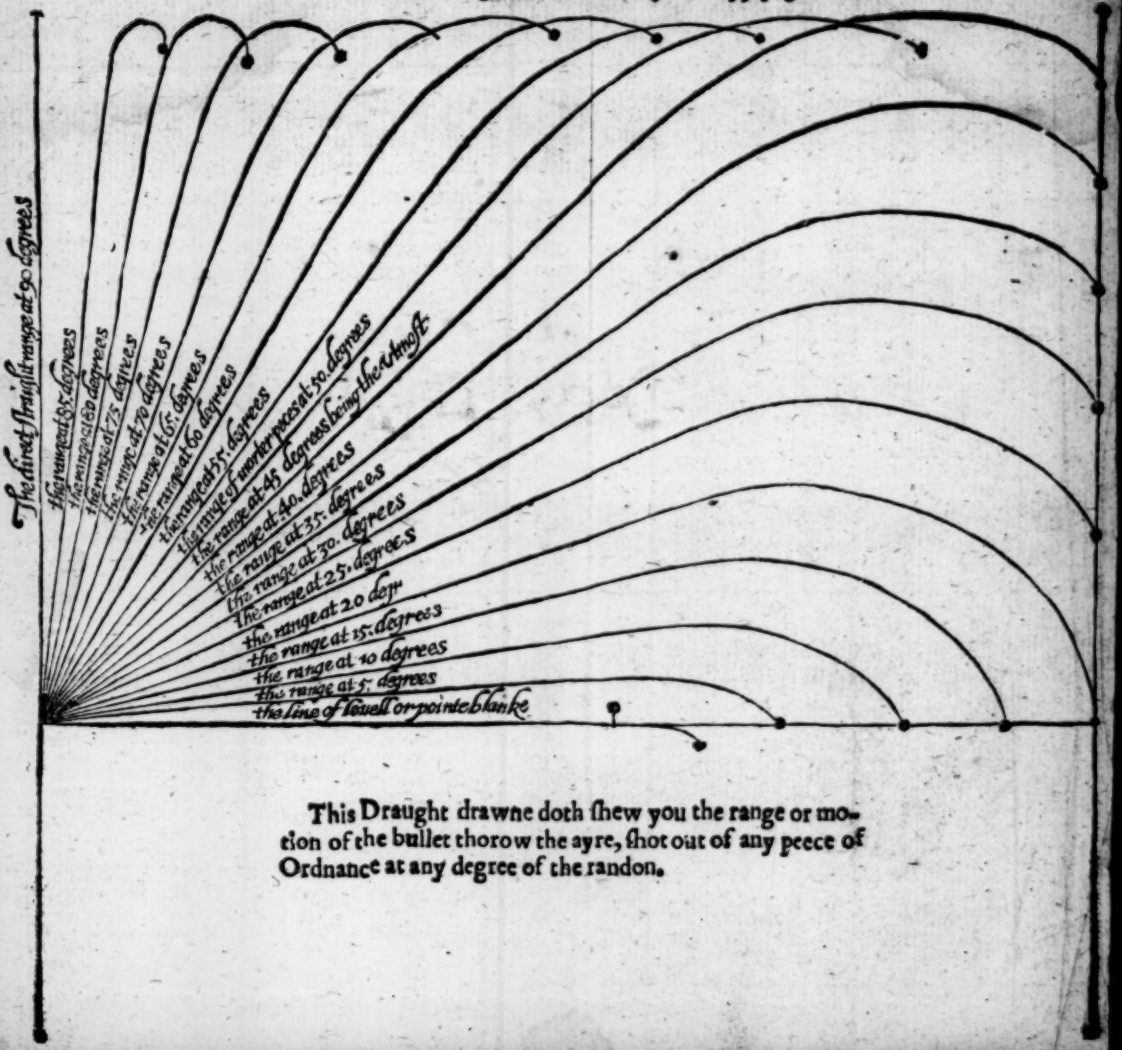


This Draught drawne doth shew you the range or motion of the bullet thorow the ayre, shot out of any peece of Ordnance at any degree of the randon.

mounted to the beſt of the randon, the plummet will cut the 45 degrée of the quadrant, as the 3 figure sheweth. Or you may make a table of randons like the other, as thus: Meaſure the diſtance the péce conveyeth the bullet at the beſt of the randon, from which abate the diſtance the péce conveyeth her bullet at point blank, divide the remaine by 45, the quotient will ſhew you how farre ſhe ſhot is carried at the mount of every degrée: or dividing the ſaid remaine by ſo many degrées as you would elevate your péce at, the quotient will likewiſe ſhew you how farre the bullet doth range beyond point blank.

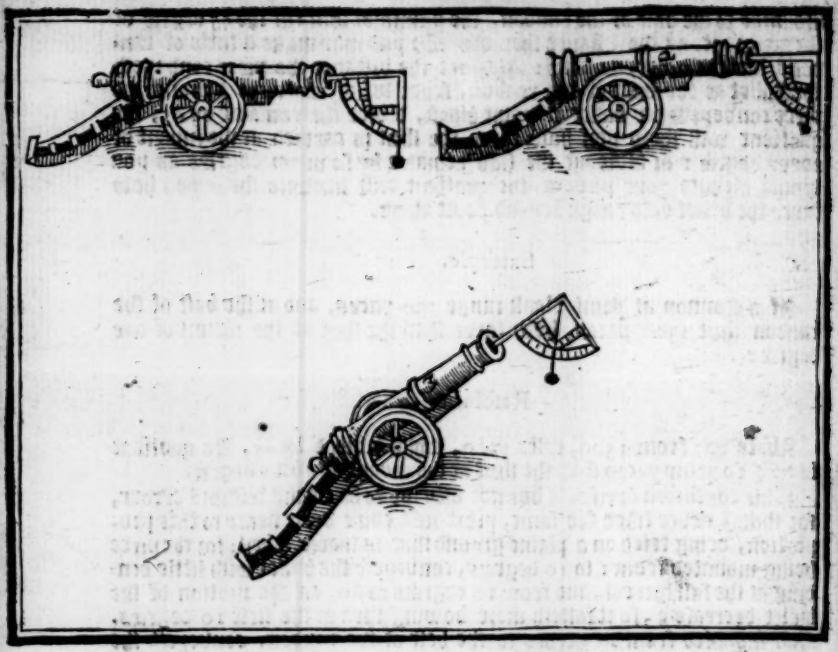
Example.

If a Cannon at point blank range 300 paces, and at the beſt of the randon ſhot 1500 paces, how farre ſhall the ſhot at the mount of one degrée?

Reſolution.

Abate 300 from 1500, reſts 1200, which divided by 45, the quotient is 26 $\frac{2}{3}$ ſo many paces ſhall ſhe ſhot at the mount of every degrée.

This concluſion or rule, I doe not affirme to be cleane without errour, for that I never tried the ſame, yet it will come very neare to this proportion, being tried on a plaine ground that is water-levell; for the péce being mounted from 1 to 10 degrées, conveyeth the bullet with little bending at the fall thereof, and from 10 degrées to 20, as the motion of the bullet decreaſeth, ſo it falleth more bowing then in the firſt 10 degrées. And mounted from 20 grades to the beſt of the randon, conveyeth the bullet in a more circular courſe. And it is to be noted, that any péce of Ordnance having her due charge, will drive the bullet more ground mounted at 20 degrées, then from 20 grades to the beſt of the randon. And being truly loaden and diſcharged at the beſt of the randon, will drive the bullet 5 times the diſtance of her levell range, or rather better.



How you may Arithmetically know how much wide, over, or short, any peece of Ordnance will shoot from the mark, by knowing the distance to the mark, and how your peece is laid to shoot at the said mark.

Question.

If a Culvering or Cannon of 10 foot long, be shot at a mark 700 yards from the peece, the mouth of the said peece planted an inch wide, how farre shall the bullet light wide of the mark?

Resolution.

Reduce the measure of the length of the peece into inches, because the denomination of wideneſſe is by inches, and the peece of 10 foot length will yeild 120 inches. Likewise reduce the length from the peece to the mark into inches, you have 25200 inches. Then by the rule of proportion say, if 120 inches shot wide one inch, what will 25200 inches? And in multiplying and dividing according to the rule, you shall finde in your quotient 210 inches, that is, 17 foot $\frac{1}{2}$: so much shall the bullet light wide

wide of the mark. For this is a generall rule, that look how many times the length of the cilinder or concave of the peece is to the mark, so many inches shall the peece shot amisse, being laid over one inch, or under, or wide of the mark, if the wind doe not alter it. The like is to be done of any other.

A remedy to lay your peece straight, if she lie either over, under, or wide of the mark.

Let a plumbe line fall perpendicularly over the middle part of the breech of the peece, and with a hand-spike or leber, winde the carriage of the peece to and fro till you espy the middle part of the metall at the mouth of the peece, and the said line divide the mark in 2 equall parts; so shall you make a straight shot, giving the peece her true disparture and length.

Another way.

Or you may take the true diameter of the concave at the mouth of the peece, laying an inch rule to the same, divide the said diameter in 2 equall parts; to the point of which division, being the center of the cilinder of the peece, let a thread and plummet fall, or else erect a squire, so as the containing angle touch the center or middle point of the diameter, by the edge of which rule or squire draw a line with the point of your knife, from the height of the metall at the mouth; that line would crosse in the center if it were continued, and it is a perpendicular or plumbe line to the other, by which line or streke so drawne, with a little peece of soft wax set up a straight straw to reach a little above the metall. And knowing likewise the middle metall at the breech of the peece, it is an easie matter to make a straight shot, if the 2 sights (*to wit*) the sight at the breech and mouth be laid so as they divide the said mark in 2 parts: for this is generall, that any three things that the eye can comprehend at once, being equall with the eye, are in a straight line from the eye, whether the same be at ascent or descent.

The line or streke thus drawne at the mouth of the peece will shew you presently where and how to set up your disparture of your peece at any occasion.

In shooting without disparting your peece at any mark within point blank, to know how farre the bullet will flie over the mark by knowing the distance to the mark.

Question.

A Cannon or Culvering of 12 foot in length, having three inches more metall at the breech on each side then at the mouth, shooting at a mark supposed to be within the levell range, and 600 yards from the mouth of the peece, being shot without her disparture, how much shall the shot flie over the mark?

Reſolution.

It is a generall rule, that lok holw much the peece is thicker of metall in any one ſide at the breech, then at the thickeſt part at the mouth, as alſo lok holw many times the length of the peece is to the mark, ſo many times that overplus of thickneſſe ſhall the bullet flie over the mark, being no higher then the peece, and the ſaid peece diſcharged without her diſparture.

Example.

Divide 600 yards (being the diſtance from the peece to the mark) by 4, (the length of the peece) your quotient is 150, which multiplied by 3 inches the overplus of metall, ariſeth 450 inches: ſo much ſhall the bullet flie over that mark, the mark being placed on the ſide of a hill or bearing bank, and within the levell range of the peece.

In like manner ſhoting at any mark within ⅓ the utmoſt range of the peece, and not diſparting your peece, you ſhall over ſhot ſomething, giving the peece her due length and due loading.

How you may lay your peece point blank without inſtrument.

If you bring the heigth of the metall at the mouth of the peece, and the heigth of the metall at the breech, equall with the horiſon, the hollow cilinder of the peece will lie point blank.

How you may Arithmetically diſpart any peece of Ordnance truly divers wayes.

If you meaſure with a paire of callepers the greateſt heigth of metall at the mouth of the peece, and likewiſe at the breech, abating the leſſe out of the greater, ⅓ the remainder is the iuſt diſparture.

Example.

A Culvering that is 19 inches high at the greateſt part of metall in the breech, will be 13 inches high at the greateſt part of metall at the mouth: which 13 inches abated from 19, reſts 6, which divided in two equall parts, the quotient being 3 inches, ſheweth the true diſparture of that Culvering.

Another way to diſpart any peece without Callapers.

Make a line and meaſure the greateſt circumference of metall in the breech, then multiply that meaſure by 7, dividing the product by 22, the quotient is the diameter or heigth of the circumference. Likewiſe meaſure the greateſt circumference of metall at the mouth, multiplying that meaſure by 7, divide by 22 as before, the quotient will ſhew the diameter of the metall at the mouth: ſubſtracting that diameter laſt found, from the diameter at the breech ⅓ the remaine is the true diſparture.

Example

Example.

A Culvering whose greatest circumference of metall at the brèech containeth 66 inches, and at the mouth 44 inches, I demand how high is the diameter of the metall both at the brèech and mouth, as also what is the true disparture of that pèece?

Resolution.

Multiply 66 by 7, ariseth 462, divide by 22, the quotient is 21, the heigth of the metall at the brèech: likewise multiply 44 by 7, you have 308, divide by 22, the quotient is 14, the heigth of the metall at the mouth, which 14 abated from 21, rests 7, the which 7 divided in 2 equall parts, yèelds 3 inches ½ for a part, the true disparture of that Culvering.

This is one of the principallest points belonging to a Gunner, to know truly how to bring the concave of the metall of his pèece even: divers other wayes there be to doe the same. As for chambred pèeces, there is no perfect or generall rule, but is to be considered according to the chamber or concave of the pèece. Every reasonable Gunner may iudge in that case.

How by Arithmeticall skill you may mount any great peece of Ordnance by an inch rule unto 10 degrees of the quadrant, if you want a quadrant or other instrument.

First you must measure the iust length of the Cannon or bore of the pèece; reduce that measure into inches, and double the same: afterwards multiply the number of inches so doubled by 22, and divide by 7, and note what the quotient number is, which quotient divided by 360 the degrees contained in the whole circumference of every circle, the last quotient number will shew you the number of inches, and parts of an inch, that will make a degrèe in the quadrant for that pèece.

Example.

Admit there is a Saker or Fawcon, whose concave or bore containeth iust 7 foot in length, and that you desire to know what parts of an inch rule will mount her to one degrèe of the quadrant, you must reduce 7 foot into inches, and you have 84 inches, that 84 doubled is 168, the which multiplied by 22, ariseth 3696, the which divided by 7, the quotient will be 528; that quotient number being divided again by 360, will yèeld 1 $\frac{7}{15}$ (that is) one inch and ½ wanting $\frac{1}{15}$ part of an inch. So I affirme that any pèece of Ordnance whose chase or bore is but 7 foot long, being mounted by an inch rule one inch and $\frac{7}{15}$ parts, that pèece shall lie iust the heigth she would have done if you would have mounted her one degrèe of the quadrant. The like order is to be observed in mounting any other pèece of Ordnance by an inch rule, of what length soever. And note, that in mounting any other pèece of Ordnance to any degrèe of the quadrant, by a Geometricall quadrant, you must put the rule of the quadrant into the pèece mouth, lifting the pèece up or downe with a leaver or hand-spike

towards the breech, till the plummet cut iust upon that degree of the quadrant you desire.

But to mount her by an inch, you must place the rule upon the highest part of the metall at the breech of the peece, coyning the peece up or downe, till through the sight or slit in your rule (be lifted to that part or division in your rule that answereth the degrees you desire) you espy the Carnoize or highest part of the metall at the mouth of the peece, and the mark, all 3 in a straight line.

If you would mount the same peece to 2 degrees of the quadrant by an inch rule, you must multiply the measure in your rule last found, being 1 inch $\frac{7}{11}$ parts by 2, in the order of fractions, and you shall have $\frac{14}{11}$, the which 44 being the numerator of the fraction divided by 15 the denominator, the quotient being 2 inches $\frac{14}{11}$ is your desire: so may you affirme that 3 inches by the rule wanting $\frac{1}{11}$ part of an inch, will make 2 degrees by the quadrant.

And note, that iok how much you would have your peece mounted by an inch rule for to answer any number of degrees under 10, either multiply that number by the number of inches and parts of an inch, that makes a degree of the quadrant, or else working as you did the first conclusion, multiplying the first product by the number of inches desired, and dividing that product by the numbers afore mentioned, your last quotient will resolve you of your desire.

Example.

I demand how much the peece afore mentioned should be elevated by an inch rule, to answer to 8 degrees of the quadrant?

Resolution.

Reduce the length of the bore of the peece into inches, as afore is shewed, doubling that measure, and it makes 168, as you see in the first conclusion: which 168 inches multiplied by 22, yeelds 3696 inches, the which product afterwards multiplied by 8, ariseth 29568, which summe divided by 7, the quotient is 4224: the same divided by 360, yelds in the quotient 11 inches $\frac{4}{11}$ parts of an inch; so many inches and parts of an inch must the same peece be elevated to with an inch rule, to answer to 8 degrees of the quadrant, as by triall you may finde.

How by Arithmetick skill you may know the true thicknesse of metall in any part of any peece of Ordnance.

Take a paire of callapers, and measure the heigth of the out side of the metall in that place of the peece whereas you desire to know the thicknesse of the metall, then with an inch rule, or else a paire of straight compasses, measure the diameter of the bore, or concave of the peece, abating the heigth of the said diameter from the heigth of the whole thicknesse of that part of the peece so measured. And note the remainder, the which

divide

divide in 2 equall parts, and the one of those parts is the iust measure of the thicknesse of the metall in that part of the peece.

Example.

I proved this conclusion with a Culvering, whose bore or concavity at the mouth was 5 inches $\frac{1}{2}$ height, and I found that the circumference or height of the whole circumference of the said peece at the touch-hole was 16 inches $\frac{1}{11}$, from the which I abated 5 inches $\frac{1}{2}$ (fraction wise) rests 10 inches $\frac{1}{2}$ parts of an inch: that divided in 2 equall parts, the quotient is 5 inches, and $\frac{1}{11}$ or 5 inches $\frac{1}{2}$ wanting the $\frac{1}{11}$ part of halfe an inch, so thick was the metall of that Culvering at the touch-hole.

Likewise I searched for the thicknesse of metall in the same peece at the end of the trunions, and I found that the thicknesse or height of the superficies of all the metall there contained 13 inches, from which I abated the diameter or concave at the mouth, being 5 $\frac{1}{2}$ inches, rested 7 $\frac{1}{2}$, which divided in 2 equall parts, the quotient being 3 inches $\frac{1}{4}$ shewed the true thicknesse of the metall at the trunions. In this order you may finde the true thicknesse of metall in any part of any peece of Ordnance.

Another way to know the thicknesse of metall in any part of any peece of Artillery.

Take a lotherne girdle, and gird about that part of the peece you desire the thicknesse of metall, lay the same measure to an inch rule, and note how many inches or other measure the same containeth; then multiply that measure by 7, and dividing the product by 22, your quotient is the true measure of the whole thicknesse of the peece in that place. Then substracting the diameter of the bore or concavity of the peece from that quotient, note the remainder. Divide that remaine in two equall parts, the one of those parts is the thicknesse of the metall in that part of the peece so measured.

Example.

I proved this conclusion with a drake Cannon of 6 inches diameter, in girding the same about with a line hard by the trunions, and laying the same to an inch rule, it contained 44 inches, which summe multiplied by 7, amounted to 308 inches; that summe divided by 22, my quotient was iust 14. And so many inches was the height of the whole metall in that part of the peece, out of which quotient I did abate the diameter or bore of the peece being 6 inches, and the remaine was 8 inches, which divided in two equall parts, my quotient being 4 inches, shewed the true thicknesse of metall in that part of the peece, being hard behind the trunions towards the breech.

And it is to be noted, that every peece of Ordnance, if it be truly fortified

tified with metall, ought to containe as much metall in thicknesse round about, so farre as the chamber where the powder and wad lieth, as the bullet is in heigth.

How to make a good shot in a peece that is not truly bored: or to know how much any peece will shoot amisse, that is thicker of metall on the one side then on the other if you know the distance to the mark.

Question.

A certaine Gunner having shot others times in a Cannon at a mark supposed to be 500 paces from the peece, findeth she shooteth still towards the right hand, and searching whether the fault were in himselfe, or some impediment in the peece, he findeth that the peece is two inches thicker of metall on the right side then on the left: And therefore requesteth how to lay the concave of the peece (being 9 foot in length) equall with the mark, so as he may make a straight shot.

Resolution.

To doe this or the like, there is a generall rule, that lok how often-times the length of the cilinder or concave of the peece is to the mark, which is easily done by dividing the distance to the mark by the length of the concave of the said peece. And knowing likewise how much the one side of the peece is thicker then the other, the one halfe of that overplus being multiplied by the quotient first found, the product will shew you how much the peece shooteth wide of the mark. And this is a generall rule, that lok which side of the peece is thickest of metall, towards that side shall the bullet fall, for that the thinner side is more smart, and the thick side more dull in heating.

Example.

The Cannon in this conclusion is said to be two inches thicker of metall more in thicnesse on the right side then on the left. And the distance to the mark is supposed to be 500 paces, (that is, 2500 feet) the which divided by 9 feet, being the length of the hollow cilinder of the Cannon, yeldeth in the quotient 277 feet $\frac{7}{9}$, the which multiplied by $\frac{1}{2}$ the superfluity of the metall being one inch, makes 272 feet $\frac{7}{2}$ still, and so much wide of the mark should the said peece have shot at such a distance, although she had beene laid full against the midst thereof.

How to remedy your peece being thicker of metall in one part then another, to make her shoot straight.

You must first search your peece with an instrument, to know which is the thicker side, then divide the overplus of metall in two parts, setting the disparture of your peece one of those parts towards the thickest

side

side of the peece mouth, and bringing the middle part of mettall at the taile of your peece, that disparture and the middle of the marke, all in one streight line, give fire and you shall make a streight shot: But beware of over-charging of such peeces, for they are dangerous.

If the thickest part of the mettall be above, then you ought to make your disparture one inch more: If under (I meane towards the carriage) an inch lesse.

To know the different force of any two like peeces of Ordnance planted against an object, the one being further off from the said object then the other.

Question.

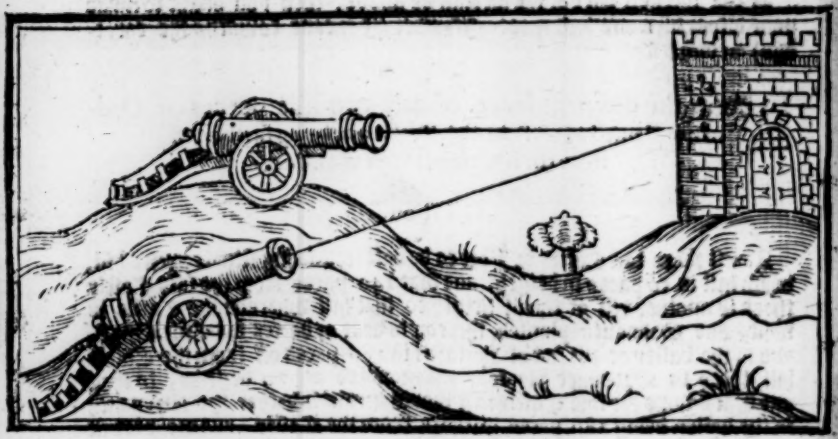
Admit there is a Castle or Fort to be battered, being situate upon a hill, which hill is 50 paces in heigth, and that 140 paces from the said Castle there is another hill of equall heigth to that hill whereon the Castle is built, and Ordnance planted thereon to beat or batter the Castle wall, and in the valley at the foot of the said hill 180 paces off from the Castle hill, there is Ordnance planted, and mounted at 20 degrées, to shoot and beat downe the said Castle: I would know whether the Ordnance in the valley being 180 paces distance from the Castle, and mounted at 20 degrées, or the Ordnance on the heigth of the hill, lying levell to shoot a little above the base of the wall, being distant therefrom 140 paces, shall worke the greatest effect in battering downe the said Castle wall, the said peeces being of like length and heigth, and having like charge in powder and bullet?

Resolution.

To resolve this or the like, a man would think that the peece planted on the heigth of the hill, lying levell to shoot a little above the groundworke of the Castle, would batter soonest, because she is nearest: yet by experience we finde the contrary, for the Castell being a great way within the reach of both the peeces, that peece shall not onely shoot much further, that is any thing elevated, but also pierce much sooner, by so much as she is able to over-shoot the other selfe like peece that lyeth levell: albeit the said peece so elevated, be planted further off from the said resisting object: for every Gunner knoweth, and reason and experience doth teach every reasonable man, that no peece of Artillery will shoot so farre at point blanke, as when the same is elevated at any number of degrées; because the bullet being ponderous, flyeth more heavily and sooner declineth, being shot out of any peece lying levell, then out of any such like peece mounted at any degrée of the randon. So that of force it must néds follow, that the peece planted in the valley 180 paces off from the Castle,

shall pierce and batter a great deale sooner then the like péce planted on the heigth of the hill being but 140 paces from it.

Example.



Example.

Suppose a Cannon or Culvering at point blank shot 240 paces, and being mounted at one degrée out shot the same 30 paces, what will the said péce doe being mounted 20 degrées?

By proportion I finde, that if at the mount of one degrée, any bullet range 30 paces beyond the levell range, that at 20 degrées it shall outlike the same 600 paces: albeit the said bullet range not in every degrée a iust like number of paces, yet the proportion will be very nére thereto. And because the péce at the foot of the hill is said to be 40 paces further from the Castle, then the like péce planted on the heigth of the hill, I abate 40 out of 600, rests 560 paces: so far would the péce in the valley out shot the other like péce on the hill, so that it must néds follow, her bullet shall pierce soorest, for that it hath most strength to dye further.

Another Example or Tryall of the former conclusion.

The péce planted upon the hill, is said to be 140 paces from the Castle, and the like péce at the foot of the hill 180 paces. Now suppose each of those péces being laid at point blank, would not range above 240 paces, that is 140 paces (the length to the mark of the péce on the hill) from 240

paces

paces her levell range, and the semitine is 100 paces; and so many paces shall that peece strike the marke before the end of her levell range.

Now to finde the like in the peece planted in the valley 180 paces from the Castle, mounted at 20 degrees, I finde by the conclusion above set downe, that the shall out-shoot the other 600 paces: so that abating the distance from the peece to the Castle, being 180 paces from 840 paces, her whole range mounted at those degrees, there remaines 660 paces. And forasmuch as the sayd peece elevated at 20 grades, doth strike the marke 660 paces before the full end of the range of her bullet, it must of force pierce or batter sooner then the other peece whose bullet beats the marke but 140 paces before the full end of his range.

How you may having divers kinds of Ordnance to batter the walls of any Towne or castle, &c. tell presently how much powder will load all those Ordnance one or many times.

Question.

There is a Castle besieged, and to batter the same there is appointed 4 Cannons, 6 demy Cannons, 6 Culverings, 8 demy Culverings, and 5 Sakers: these peeces are charged every time with corne powder, the whole Cannons shootes at every shot 32 pound of powder a peece, the demy Cannons 18 pound, the whole Culvering 16 pound, the demy Culvering 12 pound, and the Sakers 6 pound a peece. All which Peeces being 10 times discharged, did make a breach sufficient for 9 or 10 men to enter in by ranke (a breach of such a wideneſſe is thought sufficient to be assaultable,) I demand how much powder was spent before the breach was made?

Resolution.

To answer to this demand, I multiply the number of every sort of peeces, by the weight in powder that one of them shots, and the product shewes how much powder every sort of the said Peeces did spend at one bout: then I adde every number together, and the totall of that addition shewes how much will load all those Peeces one time, which addition multiplyed by 10 being the times they were supposed to be discharged, the product shewes the just quantity of corne Powder occupied at the said siege by the great Ordnance.

Example.

I multiply 32 pound the weight of Powder due to load every Cannon by 4, the number of Cannons, ariseth 128. Likewise 18 pound of powder being the duty of every demy Cannon multiplyed by 6, the number of the same Peeces, ariseth 108, and 16. pound of Corne Powder being the duty of every Culvering multiplyed by 6. the number of those Peeces, is 96. And 12 pound of Powder being the due loading of every demy Culvering multiplyed by 8. the number of the same is 96. And lastly 6 pound of Powder the duty of every Saker, multiplyed by 5 the number of that sort of Peeces, is 30. These summes or additions put together makes 458 pound weight of Powder: and so much will discharge

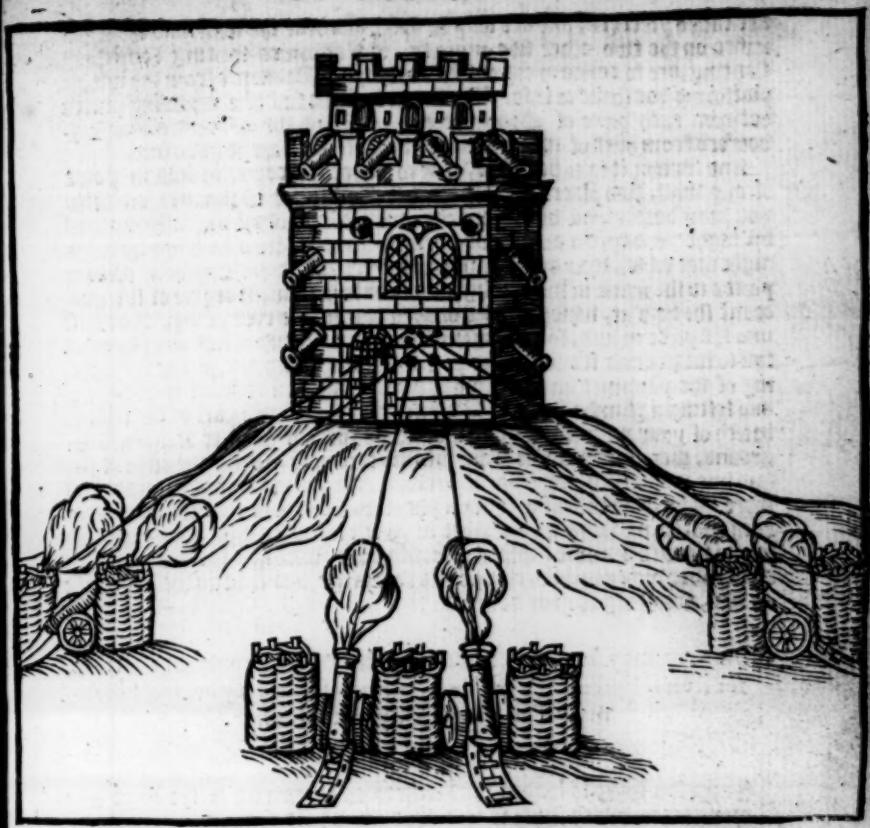
all those Peeces one time; the which summe multiplyed by 10 is 4580 pound of Powder, that is, two Last of Powder wanting 220 pound. In this order if you have 20 Last of Powder, by knowing the number of every sort of severall Ordnance, you may presently know how many shots, or how many times the said Powder will load all the said Ordnance, as this Table sheweth.

Names of the Peeces.	Number of each sort of Peeces.	Powder due to load each sort of Peeces one time.
Cannons.	4	128
Demy Can.	6	108
Culverings.	6	96
Demy Cul.	8	96
Saker.	5	30

Summe 458 pound of Powder, multiplyed by 10, makes 4580. pound weight.

And it is worthy the noting that in planting of Ordnance to batter or beat downe any Curtaine, wall, or Cullion point, you must plant the same in 2 or 3 severall places at the least, from the thing to be beat down, so as the said Ordnance be a pretty distance from each other, upon convenient plat-formes, having Gabbions or baskets about 8 foot high, ram'd full of earth conveniently placed between each Peece, to save the Gunners and Labourers from the danger of the enemies shot; which Ordnance would be planted within 200 or 240 paces of the object to be overthrowne, if it be possible to have convenient plat-formes, and to bring them so nigh the said object. The which Ordnance (if so you have made 3 mounts or platformes, the Ordnance from the two side mounts doth coyne or cut out that which the Ordnance from the middle Mount doth batter or pierce, or shake, as this draught here drawne sheweth.

The



The beſt ſhooting to batter downe the broad ſide or curtaine of any wall, is to levell ſomething under the middle part of the wall, and after to ſhoot 2 or 3 foot higher: for the lower part being beaten downe, the height or upper part of the ſaid wall muſt fall of neceſſity. And a ſpeciall regard muſt be had to give fire from each platforme or mount at one inſtant, for that the bullets beating all together, do more ſhake and batter the ſaid wall, then lighting now one and then another.

In the figure or draught which I have drawne, ſhewing how Ordnance may be planted to ding downe or batter the broad ſide or curtaine of any wall, Caſtle, or Fort, the middle Ordnance placed on the middle mount or platforme directly againſt the object to be beaten down,

are called pierc̃ers, and are only to shake and beat the wall, and the Ordnance on the two other side mounts, or platformes shoting something slanting, are to coyne or cut out that which the Ordnance from the middle platforme doe shake or lose. The baskets round full of earth being placed betwéen each péce of Ordnance are to defend the Gunners and Labourers from hurt of them that are belleged, as afore I have said.

And further it is to be noted, that to batter the coyne or cullion point of any wall, two places are sufficient to plant your Ordnance in. Also you may batter and beat downe the wall of a Towne or Castle as well by night as day, so as the enemy shall have no time to build up in the night that which was done downe in the day, as thus: Lay your péce or péces to the mark in the day light, and note well what degrée of the quadrant the lieth at, which is done in putting the rule of your quadrant into the péce mouth, so laid against the mark, letting a line and plummet fall to the ground from the said point of your quadrant, and at the lighting of the plummet on the ground, there drive in a stake or wooden pin; and letting a plumbe line fall likewise from the middle part of the taile or breech of your péce to the ground, drive therein another stake into the ground, then stretch a line from the said two pins, so as the ends of the said line may reach 2 or 3 yards further then the pins at each end: And there make them fast in driving a pin of wood or iron into the ground at each end, then bringing your péce or péces to lie straight above the said line or lines so drawne (which is easily done, having a lanterne with a close cover) you may both charge and re-charge, and shoot as well by night as day, according to your desire.

How you may know the true weight of any number of shot, for severall peeces of Ordnance, how many soever they be, and how many Ton weight they doe all weigh.

Question.

Suppose a Ship is loaden with bullets to be carried to the siege of a Towne &c. in which Ship is 500 shot for whole Cannons, 800 demy Cannon shot, 900 Culvering shot, 1000 demy Culvering shot, 1100 Saker shot, 1200 Minion shot, and 1400 Fawcon shot, the question is, to know the true weight of all the shot, and how many Ton they doe all weigh.

Resolution.

In the begining of this Treatise, I shewed how to finde out the weight of any unknowne bullet by the weight of a knowne bullet of the like mettall, so that multiplying the number of every severall sort by the weight that one of them weigheth, and adding all the products into one summe; and then dividing that totall by 2240 pound, which is the pounds in a Tonne, the quotient will shew you how many Tonne all those bullets weigh.

Example.

Example.

Admit the Cannon shot weigh 60 pound a piece, by which I multiply 500 (the number of that kinde of bullet) so ariseth 30000 pound weight: and then there is 800 demy Cannon shot of 32 pound weight a piece, which multiplied as before, makes 25600 pound weight: and then there is 900 Culvering shot of 16 pound weight a piece, which makes 14400 pound weight: and then 1000 demy Culvering shot of 10 pound weight a piece, which makes 10000 pound weight: and then 1100 Saker shot of 5 pound weight a piece, which makes 5500 pound weight: and then 1200 Minion shot of 3 pound weight a piece, which makes 3600 pound: and lastly, 1400 Faulcon shot of 2 ½ pound weight a piece, which makes 2800 pound weight. All these summes added together, make 91900 pound weight, which divided by 2240, yeelds in the quotient 41 Tonne, and 60 pound weight remaining.

In this order you may know how many Tonne weight any number of shot weigheth, so that knowing how many Tonne any ship is of burthen, you may easily know how many shot will load the said ship.

How any Gunner or Gun-founder may by Arithmetick skill know whether the trunions of the peece be placed rightly on the peece or not.

Measure the length of the bore of the peece from the mouth to the breech, divide that measure by 7, and multiply the summe that commeth in the quotient by 3, the product will shew you how many inches or other measure the trunions ought to stand from the end of the lowest part of the concavity of the said peece at the breech.

And note that the trunions ought so to be placed, as ⅓ parts of the circumference of the peece may be seene in that place whereas the trunions are set.

Example.

Admit the cilinder or concave of a Cannon, or other peece of Ordnance, be 10 foot ½ long, I demand where the trunions of the said peece ought to stand?

Answer.

Reduce the length of the concave of the peece into inches, you have 126 inches, the which divided by 7, the quotient is 18, that multiplied by 3, makes 54 inches, or 4 foot ½; so farre ought the trunions to be placed from the breech or lowest part of the hollow concavity of the said peece.

Another way.

Or multiplying the length of the concave of the peece by three, and dividing the product by 7, the quotient will shew the true place, how farre the trunions ought to stand from the lowest part of the bore or concavity of the peece.

Example.

Example.

126 inches, the length of the concave of the peece, multiplied by 3, makes 378 inches, which number divided by 7, the quotient is 54 inches, as before.

And note that the trunions of every peece were invented to hold the peece up in her carriage, to move her up and downe to make a perfect shot, and to hold her fast in her carriage after she is discharged: for if the trunions be placed too neare the mouth, the peece will be too heavy towards the breech, so as the Gunner appointed to serve with her, shall have much adoe to raise her, to come her up or downe, or being placed too neare the breech, the contrary will happen.

How yow may know what empty cask is to bee provided to boy or carry over any peece of Ordnance over any river, if boats or other provision cannot be gotten.

It is thought sufficient that 5 Tonne of empty cask will swimme and carry over a Cannon of 8 or 9000 pound weight: 4 Tonne will carry over a demy Cannon: 3 Tonne a Culverin: and 2 Tonne a Saker, accounting all provisions to be made fast thereto, as planks, ropes, &c. so that knowing what number of Ordnance is to be ferried or carried over any river, adding all their weights into one summe, by framing the Golden rule, you may presently know what empty cask is to be provided to ferry over all the said Ordnence at ons instant.

Example.

If a Cannon of 8000 weight require 5 Tonne of empty cask, how much empty cask is to be provided to carry over so many Ordnance as is supposed to be 100000 weight?

Resolution.

I multip'y 100000 by 5, so ariseth 500000, the which being divided by 8000, the quotient is 62 ½, so many Tonne of empty cask is to be provided to carry over so many Ordnance as weigh 100000 pound weight. The which empty cask made fast head to head a row on each side, by such as have skill in such services, and planked above, would serve for a bridge to carry over a whole Army with all provisions thereto belonging.

All which necessaries in time of service, and many more, belongeth to the Master of the Ordnance his office to have in readinesse: as also to be provided of Trunks, Arrowes, Bals, and all kinde of fire-works, wet or dry, and the receits for making thereof. As also engines for mounting or dismounting of Ordnance, wheeles, Axeltrees, Bullets, Powder, Ladles, Sponges, Ropes, Shovels, Anchors, &c. Also it is the duty of the Master of the Ordnance, the Master Gunner, and every chiefe Officer or Quarter Master under them, to be expert in the Art of Gunnery, the better to teach and instruct their inferiours, the which without

without some practise in Arithmetick and Geometry they cannot well accomplish. They ought to have some sight in the Mathematicalls, the better to teach and instruct such as would that at all randoms, to know what Ordnance is convenient for an Army, or to batter or beat downe the walls of any Towne or Castle, to know what powder and shot is to be provided for that or such like purpose, what carriage, horses, labourers, and other necessaries are to be allowed for the same. They ought to practise all Geometricall instruments for the measuring of heights, lengths, breadths, depths, &c. To practise how to compeigh mines under the ground, and how the same should be truly wrought to blow up any Tower, Castle, &c. To know what length the mine will containe with all his windings to and fro to the place appointed. To have skill in the handling of all engines and inventions belonging to the Ordnance. To appoint to every peece of Ordnance in time of service, Gunners that know perfectly how to manage their peeces, to charge, shot, cleanse, sponge, wad, and rank the same, and what labourers are to attend thereon. To know in every platforme appointed how to place the baskets or gabions, and what proportion of wideneſſe, height, or thickneſſe they ought to containe: and that the slopes have their due proportion of wideneſſe. To see that every Gunner be able to discharge his duty, and not for favour or affection to prefer such as can say most, and doe least: but that every man be prefered to place of credit, and esteemed according to his honeſt behaviour and skill in this singular Art. That none be permitted to the profession of a Gunner, but that he be first truly instructed in the principalls of the Art, by such as have skill therein. And not to make or suffer every ragge and ragge to be a Gunner, as is too much used in these dayes in Townes of garrison, who was never practised in the Art, nor hath discretion nor desire to practise therein: a great number of such have but only the bare name of a Gunner, although their standing hath beene of long time: for as a great many of Partizers have said 7 or 8 yeares, and yet farre from a Navigator, so a great many such have continued in pay a large prentiſe-hood, and yet farre from a good Gunner. Such in time of service would worke as the builders did at the Tower of Babell, when one called for one thing, he had delivered a contrary thing. In service the Prince by such is not truly served, the Art lesse esteemed, and themselves discredited.

The Art is like to a circle without end, or like to a Labyrinth, wherein a man being well entred in, knoweth not how to get out againe, and therefore it must bee exercise and industry that must make a perfect Gunner. Many things here could I write pertaining to the duty of a Gunner, and every Officer pertaining to the Ordnance, but for as much as the same is not peculiar to this Arithmeticall Treatiſe, and sufficiently handled by other Authours, I omit.

How to know the true time that any quantity of Gunmatch being fired, shall burne, to doe an exploit at any time desired.

Take common match, and rub or beat the same a little against some post or stole to soften it, and then either dip the same in Salt-peter water and dry it againe in the Sunne, or else rub it in a little powder and brimstone beaten very small and made liquid with a little Aqua vitæ, and dried afterwards. Now when you would occupy the same, try how long one yard will burne, which suppose to be ½ part of an houre, then 4 yards will be a iust houre in burning. Now suppose you have laid some powder or bals of wilde fire to burne some house, ship, mine, corne-stacks, &c. or that you have placed the said powder or bals in some secret place, to burne something you are desirous to spoile, and that you would be going from the place 3 houres before it effect, then binding the one end fast to the bals, laying lose powder under and about the same, or wrapping the one end like a wreathe amongst the powder losely, draw out the other end, or lay it crookedly, or wrap it softly about something, so as one part doe not touch another, and fire it at the other end; which match so drawne or rolled, being iust 12 yards in length, shall kindle the thing you would burne at the end of 3 houres, according to your desire: for the rule of proportion sheweth, that if one yard requires a quarter or ½ of an houre, that 12 yards of match will burne out in 3 houres. The like order you may observe, to answer to any time appointed.

How by Arithmeticall skill you may know what number of men, horses, or oxen is sufficient to draw any peece of Artillery, and how much every one draweth a piece, so as they all draw together.

Question.

If 90 men bee able sufficiently to draw a Cannon of 9000 pound weight, accounting carriage and all, I demand how many men are able to draw a Culbering of 2500 pound weight, and how much every man drew for his part?

Resolution.

I answer: If a Cannon of 9000 pound weight require 90 men, the quotient sheweth me that a Culbering of 2500 weight requireth 25 men to draw the same: and dividing the weight of the peece to bee drawne by the number of men appointed to draw the same, the quotient will shew you how much every man drew to his part (to wit) 100 weight.

To

To know how many horses are to bee provided to draw any peece of Ordnance, and how much every one draweth.

Question.

If three horses draw a Faulcon of 900 weight, how many horses will draw a Culverine of 3000 weight?

Resolution.

I say as before, if a peece of 900 weight require 3 horses, what will a peece of 3000 weight? and in working according to the rule, the quotient is 10, shewing that 10 horses must be provided to draw a Culverine of 3000 weight. Also dividing 3000, the weight of the said peece, by 10 (being the number of horses) there will stand in the quotient 300, shewing the draught of each horse.

To know how many Oxen are to bee provided to draw any peece of Artillery.

It is to be noted, that 3 yoak of oxen are thought to draw as much as three horses, and that three yoak of oxen are sufficient to draw a Saker of 1400 weight.

Question.

How many oxen must be provided for a Cannon of 8000 weight?

Resolution.

In working as before, I finde that 34 oxen, or 17 yoak of oxen, will serve to draw a Cannon of 8000 pound weight. And note, that whereas there doth remaine $\frac{1}{2}$ parts of a whole number, neither men, horses, nor other cattell, can in any such militeary questions be brought into a fraction, but yet the rule it sheweth that 17 yoak of oxen are sufficient for the draught of a Cannon of 8000 pound weight, when 3 yoak of oxen serve for to draw a Saker of 1400 pound weight.

If you divide the weight of the whole Cannon, being 8000 pound weight, by 34, the oxen appointed to draw the same, the quotient is 235 pound $\frac{1}{17}$; so much did every ox draw.

How you may, wanting both oxen and horses, to draw any peece of Ordnance, know presently how many men are able sufficient to draw the same, either on plain or marish ground.

Question.

I shewed in a conclusion before, that 3 yoak of oxen would draw a peece of 1400 pound weight, and that 90 men would draw a Cannon of 9000 pound weight; now if there want both horses and oxen, or that

you are occasioned to draw the said peece through some marish ground, whereas horses and oxen cannot passe, I demand how many men are sufficient to hale a Saker of 1400 pound weight through the said marish ground?

Resolution.

If a Cannon of 9000 weight require 90 men to draw the same, I finde that a Saker weighing 1400 pound weight must have 14 men to draw the same, and every one shall draw 100 weight for his part.

In drawing Artillery through any soft marish ground, it is requisite to have in readinesse, in the Master of the Ordnance his carts which carrieth the provisions for the Ordnance, certaine hurdels of woods, or rather flat bottomed boats, in which any peece of Ordnance may be placed carriage and all, and by force or strength of men may be drawne as easily, as to draw the said peece on the firme land, for that the said boat is apt to slide or swimme on the soft owish, the ropes being made fast to the fore-stearne or sides of the said boats, which boats do serve also for carriage of the Ordnance, and all things thereto belonging, over any river or soft owish ground, &c.

How you may by the rule afore know how many oxen will draw any peece of Ordnance, if you want men and horses.

I shewed that 90 men are able to draw a Cannon of 9000 pound weight, and that three yoak of oxen will serve to draw a Cannon of 1400 pound weight; now wanting men and horses, I say, if a Saker of 1400 pound weight require 6 oxen, what will a Cannon of 9000? and in multiplying the weight of the Cannon by 6, the number of oxen appointed to draw the Saker, and dividing that product by the weight of the lesser peece, the quotient is 38 oxen or 19 yoak, so many must be provided to draw a Cannon of 9000 pound weight, which weight divided by the 38 oxen appointed to draw the same, the quotient sheweth that every ox drew 236 pound weight.

How you may, wanting men and oxen to draw any peece of Ordnance, know how many horses are requisite to draw the same.

Also I noted before, that 3 horses would serve to draw a Faweon of 900 pound weight: I demand how many horses will serve to draw a Cannon of 9000 pound weight? In working as before, the quotient is 30, so many horses are requisite for that purpose: which peece, her weight divided by the number of horses appointed to draw the same,

the

the quotient sheweth that every horse drew 300 pound weight. In this order you may know what number of men, horses, or oxen, are able to draw any peece of Ordnance, and what every one severally doth draw.

How to know how many 100 of Haberdepoize weight any peece of Ordnance, or other grosse weight containeth.

In the conclusions afore set downe, thou must note, gentle Reader, that every 100 weight of most things is accounted after five score to the hundred: but if thou be desirous to know how many hundred of Haberdepoize weight any peece of Ordnance or other grosse weight containeth, thou maist by Arithmetick soone be resolved; for every 100 of Haberdepoize weight containeth 112 pound, the halfe hundred 56 pound, the quarter 28 pound, and the pound 16 ounces: so that dividing the weight of any great peece by 112, thou maist easily know how many hundred of Haberdepoize weight the same containeth.

I would know how many hundred of Haberdepoize weight is in a Cannon of 9000 pound weight; I divide the same by 112 as afore said, and the quotient being 80 $\frac{40}{112}$, sheweth that a Cannon of 9000 pound weight containes 80 hundred of Haberdepoize weight, one quarter and 12 pound.

A Tonne containeth 2000 of Haberdepoize weight.

How you may proportionally prove all sorts of peeces of Artillery for service, whether they will hold or no.

All peeces that shoot a bullet under 10 pound weight, and duly fortified with metall, being shot 3 times, first with the whole weight of the iron bullet. Secondly with $\frac{3}{4}$ parts thereof, and lastly with $\frac{1}{2}$ parts of the same, will hold for any service, being charged with her ordinary charge, albeit the said peece were discharged 100 times in one day.

How you may finde out the proportionall charge afore named, as thus.

Suppose a peece shoot a bullet of 6 pound weight, and that you desire to know what $\frac{3}{4}$ parts in powder of the weight of the bullet is: multiply the weight of the said bullet by the numerator 5, and divide by the denominator 4, the quotient is your desire.

Example.

6 multiplied by 5, is 30: the same divided by 4, the quotient is 7 $\frac{1}{2}$. The like order you must use in giving her $\frac{3}{4}$ parts in powder to the weight of the shot, and your quotient is 9 pound.

How to prove any peece that ſhooteth a bullet under 50 pound weight, and above 10 pound weight.

Any peece that ſhoteth a bullet above 10 pound in weight, and under 50 pound, would for the firſt ſhot be charged with $\frac{1}{3}$ parts in powder of the pellets weight: for the ſecond ſhot with $\frac{1}{2}$ parts: and laſtly with the whole weight of the bullet.

Example.

Admit a peece ſhot a bullet of 40 pound weight, the $\frac{1}{3}$ parts thereof is 26 pound $\frac{2}{3}$, and $\frac{1}{2}$ parts thereof is 33 pound $\frac{1}{3}$ parts.

And note, that in proving any peece of Ordnance whether ſhe be ſerviceable or not, her mouth would be mounted to 20 or 30 degrees of the quadrant, or thereabout.

To know how much one coyler rope, for the draught of any peece of Ordnance, is bigger then another, and how thick any of them are.

Take the compaſſe of the leſſer, and likewiſe the circumference of the greater, abating the leſſer out of the greater, the remaine is your deſire; which knowne, by the rule of proportion you may finde out the height or thickneſſe of the leſſer.

Example.

Suppoſe you have a coyler rope of 6 inches compaſſe, and another of 4 inches compaſſe, abating 4 inches from 6 inches the compaſſe of the greater, reſts 2 inches, the diameter or height of the greater: which knowne, frame the rule of proportion ſaying, If 6 yeld 2, what 4? the quotient is one inch $\frac{1}{3}$ parts, being the true thickneſſe or heighth of the leſſer.

To know how much one coyler rope is more then another

Take the compaſſe of your rope, and multiply it in it ſelfe, and lok how much you would have the other greater, augment your product by the ſame proportion, extract the ſquare root, you have your deſire.

Example.

A coyler rope of 6 inches compaſſe ſquared, makes 36 inches. Now if you would have one 3 times as much, then multiply 36 by 3, the product is 108, the ſquare root thereof is 10 inches and ſomething better, and ſo thick ought a rope to bee that is 3 times the compaſſe of the other.

How

How by knowing the weight of a fadome of one rope, to know the weight of a fadome of any other.

A cable or coyler rope of 10 inches compaſſe weighing 16 pound every fadome, how much will a fadom of that rope weigh that is 15 inches compaſſe, and made of the ſame ſtuffe? I multiply the greater in it ſelfe, ariſeth 225, and that multiplied by 16 pound the weight of a fadome of the leſſer rope, ariſeth 3600, the which divided by 100 being the ſquare of the leſſer rope, the quotient is 36 pound; and ſo much will every fadome of the greater rope weigh. In this order by knowing what a fadome of the greater rope weigheth, you may ſome finde what a fadome of the leſſer rope weigheth.

How by knowing the quantity or compaſſe of any ſmall rope, to finde out the ſame in another that is many times that bigneſſe.

Admit I have a ſmall rope of 3 inches compaſſe, and that it is required to know the heigth of another that is 5 times that compaſſe. I ſquare the number 3, ariſeth 9, which multiplied by 5, makes 45, the ſquare root thereof is 6 inches $\frac{1}{4}$; ſo high is the greater. The like is to be done of all ſuch like demands.

To know the weight of a whole coyler rope for the draught of any peece of Ordnance.

Queſtion.

There is a coyler rope of 8 inches compaſſe weighing 12 pound every fadome, I demand the whole weight of that rope being 20 fadome long?

Reſolution.

Multiply the number of fadoms in the rope (being 20) by the weight of one fadome, the product is 240 pound weight, your deſire.

The length of a coyler rope for a whole Cannon ought to be 70 fadome or thereabouts.

For an ordinary Cannon 64 or 66 fadome, and for a demy Cannon 60 fadome or thereabouts.

For a Culvering 40 fadome, a demy Culvering 36 fadome, and a Baker 30 fadome, &c.

To finde out the ſuperficiall content of the hollow concavity of any peece.

If you multiply the length of the cilinder or bore of the peece, by the circum-

circumference of the hollow [illegible] about the mouth, the product will shew you the superficiall co[illegible] the cilinder of the said peece.

[illegible]le.

A Cannon of 7 inches diame[illegible]bing her concave or hollow cilinder 12 foot in length, how much is the superficiall content thereof?

Resolution.

Reduce the length of the hollow concave of the peece into inches, ariseth 144 inches, which multiplied by 22 inches, the circumference of the concave at the mouth of the peece, ariseth 3168 inches, the superficiall content of the metall compassing the concave of the peece.

To finde out the crassitude or solid content of the cilinder or concave of any peece.

First you must by the rules taught in the begining of the Book, finde out the content of the base or plane of the concavity at the mouth of the peece, in multiplying ½ the diameter in halfe the circumference, or else squaring the diameter and multiplying that product by 11, and dividing the result by 14, the quotient will also shew you the content: the which multiplied in the length of the cilinder of the peece, the product is your desire.

Example.

The Cannon above named of 7 inches diameter, wrought as is shewed, yeldeth 38 inches ½ at the base or circular content of her mouth, which multiplied by 144 inches, the length of the cilinder, yeldeth 8280 inches, the solid content of the concave of the said Peece.

If you desire to know how many foot in square measure the solid content of the empty or hollow concavity of the Peece aforenamed or any other doth containe, you must work thus; divide the number of inches in the solid content thereof by the number of inches in a foot square being 1728, the quotient is your desire.

Example.

The solid content of the Peece of 7 inches diameter above named, containeth 8280 inches, which divided by 1728, the quotient is 4 $\frac{33}{54}$, that is, 5 foot in square measure wanting 15 inches. The like is to be done in any other peece, or in measuring the cilinder or Cone in any other solid body.

How you may Arithmetically know how much any peece of Ordnance is taper-bored, or whether the same bee taper-bored or not.

Put upon your rammer staffe a tampion of wood that is just the heigth of the hollow concave of your Peece, and thrust the same home into the Peece; if it go not home to the breech, then the Peece is taper-bored, if it go home the Peece is not taper-bored: if she be taper-bored, then put on

A Table wherein you may finde the names of the great Ordnance now used for offensive or defens
metall at the breech, trunions, or neck: the number of men, horses, or oxen, requisite for the a
to every peece of Artillery: And how much corne powder is requisite to charge every great peece
breadth, depth, or thickneſſe of the carriage of each peece, the diſtance each peece ſhoots at point
peece, after the account in feet and inches of Aſſize of England, and Habberdepoize weight of

The names of the peeces of great Ordnance.	The height of the diameter of every peece, in inches and parts.	Height of the bullet in inches and parts.	Weight of the ſhot in pounds and parts.	Compaſſe of the ſhot in inches and parts.	Weight of corne powder due to charge each peece in pounds and parts.	Weight of the peece in pounds about.	Length of the peece in feet about.	Thickneſſe of the metall at the touch-hole, in inches and parts.	Thickneſſe of the metall at the trunions.	Thickneſſe of the metall at the neck of each peece.
n	8.	7. $\frac{1}{4}$	64.	25. $\frac{4}{7}$	32.	8000.	12.	8.	6. $\frac{3}{4}$	4.
n Serpentine	7. $\frac{1}{2}$	7. $\frac{1}{4}$	52.	23. $\frac{4}{7}$	26.	7000.	11. $\frac{1}{2}$	7. $\frac{1}{2}$	5. $\frac{2}{3}$	3.
h Cannon	7. $\frac{1}{4}$	7.	46. $\frac{3}{4}$	22. $\frac{11}{14}$	23. $\frac{1}{4}$	6500.	12.	7. $\frac{1}{4}$	5. $\frac{2}{3}$	3.
Cannon	6. $\frac{3}{4}$	6. $\frac{1}{2}$	46. $\frac{3}{8}$	21. $\frac{3}{14}$	20.	6000.	11. $\frac{1}{4}$	6. $\frac{3}{4}$	5. $\frac{1}{4}$	3. $\frac{1}{8}$
Cannon ty	6. $\frac{1}{2}$	6. $\frac{1}{4}$	38.	20. $\frac{2}{7}$	18.	5600.	10. $\frac{1}{2}$	6. $\frac{1}{2}$	5.	3. $\frac{1}{8}$
Cannon	6.	5. $\frac{1}{4}$	24. $\frac{1}{2}$	18. $\frac{6}{7}$	16.	5000.	11.	6.	4. $\frac{3}{4}$	3. $\frac{1}{16}$
ing	5. $\frac{1}{2}$	5. $\frac{1}{4}$	19.	17. $\frac{2}{7}$	15.	4600.	13. $\frac{1}{4}$	5. $\frac{2}{3}$	4. $\frac{1}{8}$	3.
ty Culve-	5. $\frac{1}{4}$	5.	16. $\frac{1}{4}$	16. $\frac{6}{7}$	12. $\frac{1}{2}$	4300.	12.	5. $\frac{1}{4}$	4. $\frac{1}{4}$	2. $\frac{3}{4}$
Culvering	4. $\frac{1}{2}$	4. $\frac{1}{4}$	11. $\frac{3}{4}$	14. $\frac{1}{7}$	9.	3000.	11.	4. $\frac{1}{2}$	4.	2. $\frac{5}{8}$
Culvering ing Jeſſe	4. $\frac{1}{4}$	4.	9.	13. $\frac{5}{14}$	7. $\frac{1}{2}$	2300.	10.	4. $\frac{1}{4}$	3. $\frac{3}{4}$	2. $\frac{2}{3}$
Ordinary	3. $\frac{3}{4}$	3. $\frac{1}{2}$	6.	11. $\frac{11}{14}$	5.	1900.	9. $\frac{1}{2}$	3. $\frac{3}{4}$	3. $\frac{1}{4}$	2. $\frac{1}{2}$
or Minion	3. $\frac{1}{4}$	3.	4. $\frac{3}{4}$	10. $\frac{3}{14}$	3. $\frac{1}{2}$	1100.	8.	3. $\frac{1}{4}$	2. $\frac{3}{4}$	2. $\frac{1}{4}$
	2. $\frac{1}{4}$	2. $\frac{2}{3}$	2. $\frac{1}{3}$	8. $\frac{5}{14}$	2. $\frac{1}{4}$	750.	7.	2. $\frac{3}{4}$	2. $\frac{1}{2}$	2.
et	2. $\frac{1}{4}$	2.	1. $\frac{3}{8}$	7. $\frac{1}{14}$	1. $\frac{1}{2}$	400.	6.	2. $\frac{1}{4}$	2.	1. $\frac{3}{4}$

Place this Table at t

defensi services, the heigth of their diameters, their weight, and length, the thicknesse of their r the daght of each peece in time of need; the heigth, weight, and compasse of the bullet belonging peece of artillery, as also the length and breadth of the ladle fit for every peece. And the length, point blk and utmost range. And how long every coyler rope ought to be for the draught of each ght of e same.

inches and parts.	Breadth of the ladle.	Length of the planks of the carriage in feet.	Breadth or depth of each plank at the fore-end in inches.	Breadth of the planks at the lower end.	Thicknesse of the planks in inches and parts of inches.	The number of men sufficient to draw each peece in service.	The number of horses requisite to draw each peece of Ordnance.	The number of yoak of oxen fit to draw each great peece.	Distance of paces the peece carrieth at point blank about.	Distance of paces each great peece shoots at utmost randon about.	The length of the coy-
2. 1/2	15.	16. 3/4	32.	20.	8.	90.	16.	17.	300.	1500.	
2.	14. 1/2	16. 1/2	30.	18. 1/4	7. 1/2	80.	14.	15.	340.	1600.	
2.	13. 3/4	16. 1/4	29.	18.	7. 1/4	70.	12.	14.	360.	1740.	
2.	12.	15. 1/2	27.	16. 3/4	6. 1/2	65.	11.	12.	370.	1800.	
2.	11. 1/2	15. 1/4	26.	16. 1/4	6. 1/4	60.	10.	11.	350.	1700.	
1.	11.	16.	24.	15.	6.	56.	9.	10.	340.	1600.	
2.	9 1/2	18. 1/4	22.	13. 3/4	5. 1/2	50.	8.	9.	420.	2100.	
2.	9.	17. 3/4	21.	13. 1/2	5. 1/4	46.	8.	9.	400.	2000.	
2.	8 1/2	16. 1/2	18.	11. 1/4	4. 1/2	36.	7.	8.	380.	1800.	
1. 1/2	7. 3/4	14. 3/4	17.	10. 3/4	4. 1/4	28.	6.	7.	320.	1600.	
1.	6. 3/4	14.	15.	9. 1/2	3. 3/4	24.	5.	6.	300.	1500.	
1.	5.	11. 1/2	13.	8. 1/2	3. 1/2	20.	4.	4.	280.	1400.	
12.	4. 1/2	10. 1/4	11.	7.	2. 3/4	16.	3.	3.	260.	1200.	
10.	3. 3/4	8. 1/2	9.	6. 1/2	2. 1/2	10.	2.	2.	220.	1000.	

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on such a tampion of wood upon your rammer staffe, as may fill the concave of the Peece in the narrowest part where the is taper-boxed, and be sure that it goe home to the breech of the Peece, and afterwards with your compasses, measure the diameter of either tampion, abating the lesser measure out of the greater the remain is your desire.

And note that the tampion at the end of every rammer staffe, is to thrust home the wad and bullet close to the chamber or place where the Powder lyeth, and every rammer staffe ought to have a sponge at the one end, to cleanse the Peece with, and a tampion of wood at the other end, to put home the bullet and wad with, in the center of which ought to be a hollow screw wherein the Gunner may screw in a wood hooke to unload any Peece at his pleasure.

How to shoot in any Morter Peece.

Morter Peeces were invented only to annoy the Enemy, when other Ordinance cannot be used against them, as being charged with stone shot to beat downe the houses of the Enemy, or to fall amongst men being assembled together, or charged with balls of wild-fire to burne the Enemies ships, houses or corne. To make a perfect shot in one of these Peeces, it is requisite you know two things belonging to the same (that is to say,) how farre your Morter Peece will carry a bullet, or a ball of fire-work, as she is to shot at the best of the randon: and likewise how farr it is from your Peece to the mark you intend to shot at, which known you may make a perfect shot, as thus:

Example.

If a Morter Peece shot a bullet or fire-work 700 paces, and that the mark which you intend to shot at is but 500 paces; I demand at what degree of the quadrant, shall the Peece be laid at, to make a good shot.

Resolution.

To answer this and all such like, reason and experience teacheth, that the lesser ground you intend to shoot, you must raise the mouth of your Morter Peece so many degrees above the best of the randon, as is sufficient to reach the mark desired: and therefore I say if 700 paces require 45 degrees of the quadrant, what will 500 &c. and the quotient tells me, that at 63 degrees of the quadrant the mouth of the said Peece must be elevated at, to cause the bullet or fire-ball to light accordingly.

If you abate 45 degrees (being the best of the randon) from 63 degrees that the Peece was elevated at, the remaine is 18 degrees, and so many degrees of the quadrant was the mouth of the Morter Peece elevated at to reach the mark.

To know how farre or short any Morter Peece will shoot further or shorter, at the mount or dismount of one or many degrees.

Question.

A Morter Peece that shots 450 paces at the best of the randon, I would know how much shorter shall she shot, being elevated one degree above the utmost range?

Resolution.

Divide the distance of the utmost range being 450. paces, by 45 the degrees in the best of the randon, the quotient is 10, so many paces will the said Peece shot shorter, her mouth elevated one degree.

How you may know very neere how farre from your Peece the bullet shall light, the said Morter Peece mouth being raised to what degree you thinke good.

Question.

Suppose there is a Castle, &c. besieged, and that the Gunners had brought their Ordnance as neere as they would with, so that having discharged the Morter Peece in the former conclusion, at the mount of 60 degrees, they finde that the bullet falls in or about the midst of the said Castle or Fort. The question is how farre it is between the Peece and the fall of the said bullet?

Resolution.

You must first sak what difference of degrees is betwixt 60 and 45, and you shall find 15, then by the rule of proportion say, if one degree abate 10 peces, what will 45? and you shall find 150 paces in your quotient. And in this order by the help of Arithmetick you may find how far it is from the Peece to the mark.

Also it is possible to shot so directly upright in a quiet, faire, and calme day, that the bullet shot out of your Morter Peece, shall fall into the peece mouth again, or hard besides the same, if you raise the peece mouth just to 90 degrees of the quadrant, which albeit it be not serviceable, yet it is possible to be done: For this is a generall rule, that no Peece of Ordnance whatsoever can shot a bullet to continue still in a streight line, during the motion of the said bullet, except you elevate or raise the concave of the said Peece directly towards the zeneth of the skie, or else plumbe downe towards the center of the earth.

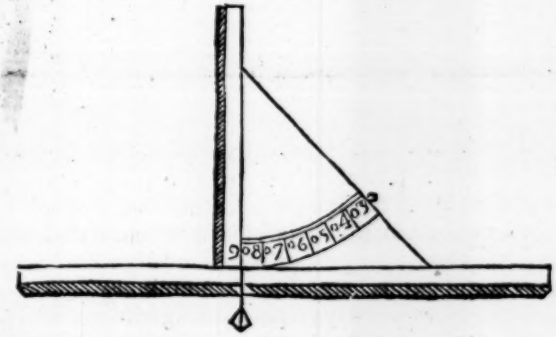
The diameter of the chamber mouth in every Morter Peece, ought to be equall to the semi-diameter in the mouth of the said Morter.

The

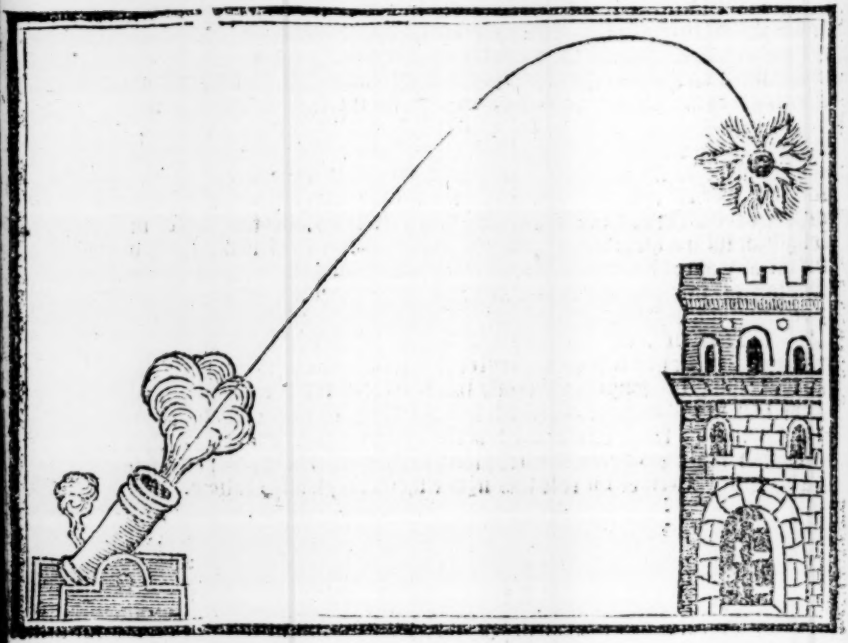
The length of every chamber in a Mortar peece, ought to be once and a halfe the diameter of the chamber.

The mettall at the breech of every Mortar peece, ought to be fortified equall in thicknesse to the diameter of the mouth of the chamber within, and at the trunions to the semi-diameter, and at the fore-part or neck of the peece, to the ⅓ part of the diameter of the chamber mouth.

To mount a Mortar Peece by the quadrant, some use to put the rule of the quadrant into the Peece mouth, close to the mettall, or inside of the peece, noting at what degree the plummet hangs; but for as much as there be many Mortar peeces a little taper bored at the mouth, (I mean the diameter at the mouth is something wider then it is within) therefore it is the best to have a rule made for the purpose, which among the experienced Gunners is common, the said rule being about 18 inches in length, at the middle point or prick whereof is another shorter rule, framed artificially about a foot long, joyned close, and falling perpendicularly on the longer rule, whose contayning angle ligheth justly on the middle point or midst of the longer rule, from which point is drawne by Art the ¼ part of a circle, and divided into 45 equall divisions or degrees, so as the 90 degree stands just on the center or middle point of the longer rule: so that laying the longer rule crosse the mouth of the peece, you shall presently know at what degree the said Mortar peece is elevated at by the plummet, the peece being mounted at any grade above 45. And thus may you mount your Mortar peece, to shoot at what degree you think good. The pattern of the rule this figure hereunto, plainly drawne.



The orderly flight or motion of the bullet or fire-ball shot out of any Mortier peece, by the figure or draught hereunder may be perceived.



Having planted Ordnance upon any mount or plat-forme, to beſiege any Towne, &c. and that you deſire to make ſome little trench or ditch about the ſame for the defence thereof, how you may know how much the earth and turfe that is caſt out of the ſaid ditch, ſhall raiſe a wall in heigth, being laid orderly at the brim of the ſaid ditch, on the inſide thereof making the ſame wall to any proportion aſſigned.

Queſtion.

Suppoſe the Generall command the Captaine of the Pyoners, that a ditch be made about the mounts or platforms where the Ordnance plant, making the ſame 18 foot in breedth at the brim, 12 foot in breedth at the bottome, and 8 foot in depth, and that the earth and turfe digged out of the ſaid

ſaid trench be laid orderly in the inſide thereof at the brim of the ſaid ditch, ſo as a wall may be made in breadth at the bottom 12 feet, and at the top 8 feet, I demand how high ſhall that wall be when it is finiſhed?

Reſolution.

To work this, there is a generall rule, (as thus) Adde the wideneſſe or breadth of the brim, and the breadth or wideneſſe at the bottom together, the ½ of that addition multiplyed by depth of the ditch, the product of that multiplication ſhall be your dividend or number to be divided. Now to find the height of the wall, adde the thickneſſe of the bottome of the wall which you mean to make, to the thickneſſe or breadth that you intend to make it at the head; the ½ of that addition ſhall be your diviſor, which dividend divided by the diviſor, the quotient will ſhew you the height of the wall.

Example.

The trench in this concluſion is ſaid to be 18 feet broad at the mouth or brim thereof, and 12 feet at the bottom, which 2 numbers being added, makes 30, the halfe whereof is 15 feet, which 15 feet multiplyed by 8 feet, being the depth, ariſeth 120 feet for my dividend. Likewiſe, adde twelve feet (the thickneſſe of the wall at the bottome) to 8 feet the breadth you meane to make it at the head, ſo ariſeth 20 feet, the ½ thereof is 10 feet for my diviſor, (and ſo thick the ſaid wall will be in the midſt: the which dividend being 120, being divided by the diviſor 10, the quotient is 12, and ſo many feet in height ſhall the earth and turfe caſten out of the trench aforeſaid, make a wall being 12 feet broad at the bottom, 8 feet at the head, and 10 feet in breadth at the midſt: the ſaid trench being 18 feet broad at the brim, 12 feet broad at the bottom, and 8 feet deep.

In this order you may find out the height, breadth, or depth of any ſuch like wall or ditch, in making the ſame after any proportion aſſigned.

Briefe obſervations of certaine principalls in the Art of Gunnery, for every Gunner to conſider of, to practiſe and learne, viz.

To know what diſparture every peece of Ordnance ought to have in ſhooting either at or within point blank, or with an inch rule at any advantage.

To uſe a mediocrity in ramming and wadding, and in giving every peece her due loading in powder and bullet.

To know the goodneſſe and badneſſe of powder, and how to mix and make perfect good powder, and how to fine the peter, &c.

To conſider the wind, whether it blow with you or againſt you, or on any ſide of the Peece, and how to weather your Peece to make a good ſhot.

To conſider the plaiſome, whether it be flat, or riſe declining for the

recoile of your Péce, and whether the mark be higher or lower then your platforme, as also to know the distance thereto.

To know whether your Péce be truly bored or not, and how to make a perfect shot in a Péce that is not truly bored.

To consider whether the one wheele be more glad or reverse faster upon the axle-tree then the other, or whether the one wheele stand higher then the other, lest you doe that wilde.

To know whether a short Péce will out-shoot a long Péce or not, keeping the length of the mark by the like degrées of the quadrant.

To know that levelling with the quadrant towards a hill (the marke standing higher then your platforme) you shall shoot short: and shooting into a valley, you doe over-shoot the mark, but shooting on a level ground you keepe the length with the quadrant, and how you ought to lay your péce to make a perfect shot with the quadrant at every mark.

To know that giving levell with an inch rule (which some call the rule of flat) it is erroneous in shooting in Péces of contrary length, as also at levell all marks observing one method.

To learne to know the distance to the mark, and what distance your Péce will shoot at point blank, or mounted from degrée to degrée, which is the best rule to shoot by.

To know whether the carriage or stock of your Péce have her due length or not, and whether the péce be truly placed therein or not.

To consider that in shooting divers péces from one platforme, to discharge that péce which stands to the leyward first, and to set your match or fire ever on the ley side, and your powder on the wind hand.

To know the true order in mixing and making all kind of fire-works, wet and dry.

To know the heigth and weight of all péces of Ordnance, and whether the same lye streight in the carriage, or not.

To know the heigth and weight of all bullets of like mettall, and the circumference thereof: and what proportion a bullet of one mettall beareth to the like or unlike bullet of a contrary mettall.

To know how much Serpentine or corn powder is requisite to charge any péce of Artillery.

To know what necessaries belongeth to any péce of Ordnance, being in service by Land or Sea; as ladles, sponges, hand-spikes, ropes, coines &c. and what labourers should attend the same.

To know likewise what men, horses, or oxen, are able to draw any péce of Ordnance in service, or on the sudden.

To be circumspect of lighted matches and candles, &c. for feare of powder, being in sea-service: and to keep a perfect register of every thing pertaining to your Ordnance, both what you have present, and what you have spent, to keep your Ordnance dry within, and to have in readinesse all kind of serviceable fire-works, which fire-works ought to be made either in the boat or on land, but not in the ship for feare of hurt.

I will.

To

To know the use of all Geometricall instruments belonging to the profession of a Gunner, as also to have some sight in Arithmetick and Geometry, thereby to shoot at all randons, and how to mannage and handle all engines for the mounting or dismounting of any Peece of Ordnance, in or out her carriage, &c.

To know that every Peece ought to be as thick of metall in every part from the lowest part of the concave at the breech, to that part of the chamber that holds the Powder, as the bullet due to that Peece is in heigth.

A breviary of certaine secrets in the Art of Gunnery.

A bullet violently driven out of any Peece of Ordnance by the force of the Powder, flieth swiftest and straightest from the mouth, till it be past $\frac{1}{3}$ the distance of the levell range.

The great noise or roare that the Peece makes in delivering the bullet (or discharged without a bullet) ariseth betweene the ayre within the Peece, violently driven out into the open ayre by the force of the fire (the Petre or Master being resolved into a windy exhalation.) And according to the quantity of the fire and ayre, bursting out of the Peece, so is the crack more or lesse.

Any bullet shot out of a Peece lying levell, doth flie more beatily, and worketh lesse effect in pierc'ing an object, then when the Peece is elevated at any degree or degrees of the random.

A heavy bullet violently moving, pierceth surer then a lighter bullet, having the like motion.

A bullet of lead shall work as great effect against an object, as the like bullet of iron, having the like motion, by reason of his overplus of weight.

A bullet shot out of any Peece of Artillery will pierce more against any thing standing firme, then against a moveable object, and shot at an object a reasonable distance from the Peece, will pierce more effectually, then shot at the same nearer hand.

Every bullet doth make a long or short range, according to the elevation of the Peece out of which it is shot.

A bullet flieth ever furthest in his straight motion (or in an insensible straight line) the higher that the Peece is elevated at the mouth.

Any Peece discharged twice with one and the selfe like quantity of Powder, wad, and bullet, having one and the selfe like proportion in ramming and wadding, and shot at one like degree of random, the Peece of like temper at either shot shall make like ranges; but the said Peece discharged as afore, but not of like temper, shall make severall grazes.

Two Peeces in all respects equall, save only that the one is something longer then the other, discharged with one like quantity in Powder and bullet, shall make severall grazes, according to the length of the cilinder of the Peece, the longer shall out-shoot the shorter.

Two Peeces in all respects equall, save only in length, discharged at a mark of equall distance from each Peece, and being within the range of both Peeces, the bullet shot out of the shorter Peece shall graze or beat the mark, before the bullet shot out of the longer Peece.

Two Peeces proportionall in all respects, being discharged with one like quantity and kinde of Powder, but differing in bullet, as the one iron, the other lead, and both bullets of like heigth, shall make severall ranges, the iron bullet shall out-flie the leaden bullet: but discharged with a bullet of metall, and afterwards with a like bullet made of wood, observing one and the like quantity in Powder at every shot, the bullet of wood shall not flie so farre as the like bullet of metall.

A Peece any whit elevated at the mouth, will shoot further in an insensible straight line, then lying levell: and by how much more any bullet is driven more swifter through the ayre, by so much it is made the more lighter in the moving or drift thereof.

Two Peeces alike in every respect, shot with one like bullet, but different quantity of powder, shall make severall ranges. Also the said peeces and bullets equall in all respects, and the powder also in quantity equall, saving that the mixtures of the said powder is not alike, shall make severall ranges.

One Peece discharged divers times with one like bullet, first with the quarter of the weight of the bullet in powder, after with halfe the weight, thirdly with ¾ parts of the weight, and lastly with the whole weight of the bullet in corne powder, and the ranges differing at point blank noted, the ranges at the utmost random differing shall be proportionall, one method in charging, &c. being observed.

To every peece of Ordnance, according to the proportion of the diameter, length of the cilinder, and weight of the bullet belonging thereto, there is a due quantity of powder to be allowed, so that charging the peece with more or lesse then the said due proportion, shall rather hinder then further the bullet in his furthest range.

By how much the metall of any Peece is made hotter by often shooting, then it was before you made the first shot, by so much is the concave or bore of the peece made more attractive, the metall more dulled, and the Peece worketh lesse effect then in the beginning.

All Peeces in whose metall is mingled most tinne, lead, or copper, is more attractive a great deale then those Peeces in whom is put most bell-metall.

A brasse Peece made hot with often shooting, is more apt to break then when it is cold; and any Peece of Artillery is more apt to break at the first or second shot, in a hard frost, being cold, then made hot with often shooting.

Any Peece of Ordnance discharged, having her full charge in powder, will range and pierce further, then wanting any part thereof; and having a little quantity more then her due charge in powder, will over-shoot the other, but it will danger the Peece; but doubling the weight of the bullet

bullet in powder, shall shoot lesse ground then having a meane proportionall charge in powder (to wit betweene ⅓ parts and the whole weight of the bullet) for that the cilinder of the peece is too much choked, and the bullet driven out into the open ayre before the powder be all fired.

Every Peece of Artillery ought to have her convenient length and weight of metall, according to the proportion of the diameter of bore of the same, and being made longer or shorter then her said due length, will rather hinder then further her utmost range.

Any Peece of Ordnance made hot through much shoting, will neither range so farre, nor pierce so deepe, as being temperately cold.

No Peece of Artillery can shoot a bullet to range still in a perfect straight line, except you shoot the same either directly upright, towards the zeneth of the skie, or else directly plumme down towards the center of the earth.

The right line of the utmost randon in all peeces is more then the right line of the levell range; and the right line of the utmost range is not so much as the right line of 90 degrees.

The utmost range in all sorts of peeces is not at iust 45 degrees of randon, as Tartallia and divers others doe affirme, but shoting with the wind in a quiet or calme day, is at or about 45 degrees; but the wind against, or on any side, or rough, or the ayre thick, &c. will range as farre at or about 40 degrees.

Two peeces in all respects equall save only in length, discharged with a like quantity in powder, wad, and bullet, and shot at a mark within the reach of both peeces, mounted at like degrees of randon with the quadrant, the shorter peece shall out-shoot the longer.

The right lines made by any two peeces at one degree of randon discharged, are proportionall to the ranges of their bullets at the same degrees of randon, and the right lines made by any two peeces at any randon, are proportionall to their utmost ranges.

Any peece of Ordnance first discharged with the whole weight of the bullet in Serpentine powder, and after discharged with ⅓ the weight of her bullet, in such corne powder as shall cause the peece to range the same ground: and lastly discharged with halfe the quantity of either sort of powder, the second ranges shall not be equall, although the manner of charging and temper of the peece be all alike.

Three peeces in all respects equall, save every one exceeds other in like proportion in length, the utmost ranges of their bullets shall not be alike proportionall, although the forme of charging be uniforme and alike.

A peece twice discharged, first with an iron bullet fit for the same peece, and after with a leaden bullet of the like weight, but differing in height, and with one and the like quantity in powder and wad, at either time the iron bullet shall out-flie the leaden bullet.

A peece discharged first with an iron bullet, and after with a leaden bullet of like height, and at either time discharged with the weight of the bullet in Serpentine powder, shall make unequall ranges,

A peece twice discharged at like degree of randon, first with an iron, and then with a leaden bullet, and after discharged with any other quantity of powder, the ranges of the bullets shall not retain the same proportion.

If two peeces of one length, but differing in bore, the one discharged with an iron, the other with a leaden bullet at one like randon, having the weight of either bullet in course powder, do range both alike ground, and the said peeces after discharged with halfe the weight of their bullets, of the same or any other powder, shall not range one like distance of ground.

Two peeces of one metall and length, but of different bullets equally mounted, discharged with any like quantity of one powder, shall not range iustly one distance of ground.

The proportion of the different ranges that iron and leaden bullets make, being found by experience in any one peece of Ordnance, the same proportion will not hold in all other peeces of Ordnance of contrary length, that shoots the same like bullet.

Any peece of Ordnance being thicker of metall on the one side then on the other, discharged at a mark, will cast the bullet towards that side that is thickest of metall.

Two peeces of contrary length, but of like diameter, having both one like charge, being shot off at a mark within the reach of both peeces, giving levell with an inch rule, at one like height of the rule, shall make severall grazes, the shorter peece shall out-shoot the longer.

Any peece of Ordnance will convey the bullet more ground, her mouth elevated at 18 or 20 degrees, then from the said grades to the best of the randon, although there be 7 degrees vantage in the later.

Any peece of Ordnance, having her due loading, will convey the bullet more then five times the distance of her levell range.

A Table

A Table ſhewing the Contents of this Book.

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FINIS.

CERTAINE

ADDITIONS

TO THE

Book of Gunnery.

WITH A SVPPLY OF Fire-Workes.

All done by the former Author, *Thomas Smith*, Souldier of *Barwick upon Tweed*.
Both pleasant and profitable.

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How
Bo[illegible]
1673

LONDON:
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Certaine Principall Points belonging to the Art of Gunnery.

I Read in Tartaglia of Powder that shall make no noise being fired out of any peece of great Ordnance, where he saith it is not lawfull to be used, neither to shew the making of it, but I am assured he never burnt any of it: for he doth confesse in his Epistle to his booke, that he never shot in any Peece. Also I have heard it confidently affirmed, that there is forcible powder (of a white colour as they say) the which being fired out of any Peece of Ordnance, the Peece having had her due loading thereof, it shall make no roze, crack, or report (as we tearme it:) but I neither beleeve the one nor the other. For I say, it is impossible to make Powder that shall burne and have any force, but that the flame thereof being resolved into a windy substance, enclosed within the concave of the Peece, violently thrusting it selfe out of the Peece into the open ayre, must of necessity give a roze or crack, more or lesse, in proportion to that ayrie substance so fired and compassed within the Peece: many examples I could alledge for further proofe hereof.

The vertue and force of Gun-powder consists in the Saltpeter, for the Brimstone and the cole is but only to maintaine the flame thereof: for the Brimstone it selfe is apt to flame with any sparkle, and once flamed causeth the Matter or Saltpeter to flame. The cole is apt to kindle or burne with any sparkle, but not to flame, yet maintaineth the flame of the other two materials. The best Matter is that which is refined without any fatnesse. The best Brimstone is that which hath no drosse in it. And the best cole are those that are made of the softest and lightest wood. These three materials being pounded very fine, and their true proportioned parts mixed and wrought accordingly by such as have skill in

the Art, makes perfect good powder: the use whereof was never better known then in these present dayes: the goodnesse of any powder may be known by the colour, by the taste of the tongue, and by the burning, and a man may make as much and as little thereof at a time as he pleaseth, having provision of furniture for that purpose.

Any Peece discharged divers times with moist powder, will sooner heat then being discharged the like number of times with like quantity of fine dry powder: for the moist powder is longer in burning and causeth the peece to work lesse effect then if it had been charged with like quantity of dry powder.

If you have by experience found that your powder is not forcible, the nearest way to strengthen the same is, by putting to every pound thereof one ounce of refined Saltpeter finely pounded, and then moistening the same with vinegar or rather the water of Saltpeter, and beating the same in a morter or other vessell as finely as you can, with a wodden pestell (for it is dangerous to beat the same with any iron tole for feare of a spark) and sifting the same through a very fine sieve, corning and drying the same, it will be of more force a great deale then it was at the first time. Some doe make excellent good Corne powder, so fine, that the Cornes thereof are like Thimeseed.

I have read and heard some of that opinion, that if a little quicksilver be put in amongst the powder wherewith any peece is loaden, and a close wad thereafter, that that peece shall give a greater report then if she had been charged with the same like quantity of powder and wad and wanting the quicksilver, the which I did experiment in a Calliver, but could perceive no such matter.

If you would out-shoot any other man in any one peece of Ordnance, the peece to be loaden at either time with one like quantity of one like powder, wad and bullet, and discharged at one like random: then after you have loaden the peece with her due of powder, put the same closely home with the end of your rammer staffe, and after make a round wad as hard and close as you are able to thrust home to the powder, and put your bullet close home to the said wad, but put no wad after it, if the mark lye so as the peece mouth be any whit elevated: otherwise put in a little wad after the bullet, to keep the bullet close to the wad in his right place.

Also if you strong canvas soaked in oyle, and sowe the same close and round about the bullet, that the bullet may fill the hollow cilinder of the peece, and put the same close home as afore, that bullet will range further then being discharged having a lesse wad, and being uncoated. Tartalia affirmes, that the powder put into the peece and ramd home to the breech, being bored through with a staffe of an inch or ¼ in thicknesse, to the breech of the peece, and after a close wad put home to the said powder, and the bullet put home after it, that that bullet shall range more ground then it would have done if the powder in the peece had not been bored through, as is aforesaid.

Any

Any peece being charged with very dry powder, that is hard corned, shall not fire all the powder, but a great many of them comes will passe out of the peece unburnt when the peece is recharged, as you may by experience prove out of a Musket or Calliver: and the closer that the wadde is made that is put into the Peece after the Powder, it will cause more of the Powder to fire, then having a lesser wad.

Any peece of Ordnance although the same be loaden with very good and dry powder, if the peece lye long loaden, the powder will grow moist, by reason the Salt-peter will work and grow dankish within the chamber of the Peece where the Powder lyeth: and if the said peter be not well refined, it will sooner grow dankish then that which hath been well refined: also the same will grow moist sooner in the winter then in the summer, and sooner on the sea then on the land.

Two Peeces in all respects equall save length, at point blank, or at any degree of the randon, discharged with one like bullet and quantity of powder, the longer peece will still out-shot the shorter: but giving the shorter peece a more quantity of powder then the longer, the shorter peece will out shot the longer.

A Musket that shooteth ½ parts or ⅓ in powder of the bullets weight that is fit for the said Musket, will range further and pierce deeper then a Calliver that is recharged with a fit bullet and ½ parts or ⅓ parts of his bullets weight: but in giving to either peece a like proportion of powder, I mean giving the Musket but ½ parts in powder of the weight of the Callivers bullet, then shall the Calliver doe more execution and range further then the Musket. And in like case a Fawcon or Saker being discharged with the whole weight of powder of the bullet fit for the said peece, shall doe more execution, and range further then a Cannon or Culvering that shooteth a fit bullet, and hath but the like quantity of powder that the lesser peece hath.

Any peece of Ordnance that is presently recharged after her loading, or that hath not lien long loaden, will convey her bullet more ground, and doe more execution then letting the same peece lye long loaden, the peece discharged at either time at one like degree of randon, and with one like quantity of one like powder, wad and bullet.

Two peeces in all respects equall, both loaden alike with one like powder, and laid at the mark from one like platforme, the center of the mark fast point blank with the center of the hollow cilinder of the peece, and within the level range of both Peece, the one of the said Peeces brought to the mark with her true disparture, and the other Peece with her metalls, that peece so disparted shall strike the mark, and the other Peece shall shot over the mark.

A bullet of any metall discharged out of any Peece of Ordnance, by how much more violent or swifter it is driven through the ayre, it is in-

proportion to that violent moving so much the lighter, and the more lighter the more easie is the passage thereof; and the more forcibly it flyeth, the more force it worketh against any resisting object, and flyeth in a streighter line in his swift motion then in his decreasing moving. And by how much the swiftnesse thereof decreaseth, in like proportion to that moving doth it grow heavier and declineth.

A bullet of iron or any other mettall that is not solidly cast, but hath in it some little hole or empty place, being discharged out of any peece of great Ordnance, doth flye through the ayre with a more whistling sound then if the same had been perfectly solid and round cast. And any bullet recharged from any peece of Ordnance, will make a greater sound passing violently through the ayre at the first shot, then at the second, third, or fourth shot, being recharged one presently after another, by reason the ayre at the first shot was quiet, close, and undivided, and therefore of force must resist the passage of the bullet, more then when the same is moved or divided.

The violent motion of a bullet discharged out of a Cannon or Culverin, or other such like great peece of Ordnance, passeth with such a strong motion, and driveth the ayre before it in the passage or range thereof, that flying over houses three or foure hundred yards above the same, doth often shake them in such sort, that the glasse on the windows will breake in peeces, and the platters on the benches or such like things standing lose will fall down, and the higher that such houses are that are so under the passage or range of the bullet, are more subiect to the hurt or shake thereof then lower houses which are nearer to the peece, and under the like range of the bullet, which is a strange thing, that the motion of the ayre driven and driving the bullet, should have such a power to shake or hurt a great object rather then a lesser, both standing under the like passage of the bullet. Also it hath more power to hurt an object standing fixed (though further from the peece) then a moveable object, as a man or beast, being much nearer to the peece, and both under the range or passage of the bullet.

Any peece being discharged with her due loading in powder and wad, with a fit bullet of iron, and after being discharged with the like quantity of like powder and wad, and with a bullet of lead of like diameter to the iron bullet, shall make severall ranges, though the peece be discharged at one like grade, the bullet of iron shall outflie the bullet of lead; but loading the peece with her due of powder according to the weight of the iron bullet, and after loading her with the same powder, giving her the like proportion to the weight of the leaden bullet, the range of the leaden bullet shall extend further then the range of the iron bullet.

Two peeces of like bore, but contrary length, having one like loading, and laid at one like degree of the quadrant, to shot at any one mark, without the severall range of each peece, but within the best random of both peeces, shall make like ranges: but if the said peece have one like visuall sight (to wit) if they have both one like length given them by an inch rule,

rule, to reach the ſaid mark (which ſome Gunners call the rule of flat) the ranges of thoſe two peeces ſhall greatly differ; and though they have both one like length given them by the ſaid rule to reach the mark, yet ſhall they alter by the degrees of the quadrant, the ſhorter peece ſhall be elevated at a higher point then the longer, and therefore of force muſt range further then the longer.

It is a common opinion amongſt a great many Gunners, that any peece of Ordnance lieth point blank that is truly brought to the mark, whether the ſaid mark be aſcending or deſcending, the peece laid truly againſt the ſaid mark without any length given to reach it: but I ſay, that there is but one preciſe point blank, that is, when the peece is ſo laid that the line iſſuing from the center of the hollow cilinder of the peece cutteth the center of the mark; and if it were or might be extended forthright would cut directly the true horizon; or a point blank or levell line is that which by ſuppoſition extendeth it ſelfe from the centre of the peece through the centre of the mark unto the true horiſon; for there can be but one preciſe ſtraight line or point blank as the Gunners tearm it, which muſt be that viſuall or ſuppoſed line, whoſe ends are both of equall heigth. Or a direct ſtraight line is that which when a perpendicular line falleth thereon, devideth it into equall angles, as is taught in Euclid and other books of Geometry. The eaſieſt and trueſt way to know when your peece lieth point blank, is by putting your rule into the peece mouth, having a Gunners quadrant or ſquare thereon, and coyning your peece ſo, that the plummet may cut or fall on the line that makes the right angle from the center where it hangs (called the levell line) that peece then lieth point blank: all other lines viſuall being extended to any mark that is either higher or lower then the eye, are not to be tearmed ſtraight lines.

If the mark you are to ſhoot at be in a ſtraight line with the concave of the peece, and not without the point blank or levell range of the peece, it is an eaſie matter to ſtrike divers marks ſtanding in the ſaid line, by making the viſuall line ſo much lower, as is between the true viſuall line and the center of the cilinder of the peece, being the line in which the bullet flyeth: and if the mark be farre without point-blank, it is poſſible to ſtrike two markes ſtanding in the viſuall line, both in the place where the bullet firſt cutteth the ſaid viſuall line, & ſo rangeth above it into the ayre in his ſtreight motion (which will not be farre from the peece) and in that place where the bullet in the end of his range declining, cutteth the ſaid viſuall line again in his craked or bending motion, which muſt of neceſſity be either at or very neere to the mark.

If the mark you mean to ſhoot at be not far without the levell range of the peece, and ſomething higher then point blank, then muſt you ſo lay the peece, that the viſuall line aimed by the ſuperfices of the metals of the peece (not diſparting the ſaid peece) may cut the mark: and if at the firſt ſhot the bullet light ſhort or over, you may eaſily amend the ſecond by adding or abating the length given; but if the mark be under point blank, and not farre without the levell range of the peece, then ſet up your diſpar-

pasture in the midst of the superfices of the metall at the mouth of the peece, and working as is said by experimenting one shot, it is an easie matter to make a perfect shot the second time: and if you shot at the said mark not disparting your peece, then must you lay the peece short of the mark, that the usuall line passing by the mettals of the peece touch a pretty distance under the mark.

All marks or objects distant from your peece, which you are to shot at, are in a triefold proportion to be considered of, as either the same is just point blank, which is in one respect only to be considered of, or it is higher or lower then point blank, which is to be considered of in divers respects, according to the distance and number of degrees the same is at, either in ascent or descent.

Any two or more peeces of like or contrary proportion at point blank discharged, every peece having her due loading with powder, and with a bullet fit for each peece, and the levell ranges of the said peeces noted, that of those peeces whose levell range is furthest, will still out-shot the other at any grade of the randon, giving to every of the said peeces the self like loading in powder and bullet.

Any 2 peeces differing in proportiõ, & the difference of their level ranges knowne, may so be loaden, as they shall both range one like distance of ground at one like randon: & the utmost range of any peece known at any degree of randon, by abating the proportion of her powder, it is possible in two or three shots, to shot any part of the same randon that you will assign.

Two peeces in all respects equall save length, mounted one like degree of randon, and loaden with one like weight in contrary powder, and with one like bullet, that peece that is loaden with the best powder, will still out-range the other, although that other be the longer: but if there be but little difference betwixt the force of the powders, this proportion will not hold at every grade of the randon.

To charge any peece of Ordnance Gunner-like, set your boudge or barrell on the wind hand of the peece, and causing one of your assistants to hold the same aslope, thrust your Ladle into the same, filling it full of powder, causing your fellow that holds the boudge to strike the same with a ruler; two of those ladles is the common charge of that peece. And firing your thumb just under the staffe of the ladle, thrust the same home to the chamber of the peece where the powder lyeth, turning the ladle so as your thumb be directly above the staffe, and in so doing the powder will fall or turne out of the ladle cleanly, then drawing out the said ladle with the tampion on the other end of the staffe, thrust home the powder with 2 or 3 strokes, causing your assistant to hold his thumb close on the touch-hole of the peece; then taking a close round wad of hay, tow, untwisted rope, or such like, thrust in the same with your rammer-staffe close to the powder: and after put in the bullet close to the wad. And if your peece be elevated at any degree of the randon to reach the mark, it is needlesse to put in any wad after the bullet, for it will rather hinder then help the same: but if the peece mouth be any whit embased,

then

then it behoveth to put in a wad close to the bullet to hold the bullet in his right place: and the speciall point belonging to a Gunner in charging of any great peece, is to loade the same standing sidewise of the peece, and not directly before her mouth; for it sometimes happeneth, that a peece having flawes or honey-combs within her, being often discharged together, doth for a season kep some sparks of fire in the said holes, so that thrusting home the ladle with the powder to load the peece, standing directly before the mouth of the peece, it taketh fire and killeth the Gunner and such as are directly before the mouth of the peece, as happened in Anno 1573. at the siege of Edenbrough Castle, to two experienced Gunners, who if they had stood sidewise to the peece, might have escaped that danger.

If you charge your peece with a cartredge, and having put the same home to the breech with the end of your rammer staffe, put after the same a good wad, and after that the bullet, as afore is taught, not forgetting to thrust the case of the cartredge through with your priming iron in the touch-hole of the peece, that the priming powder may be sure to take hold and to fire same. Some use to put a tampion of wood in next to the cartredge, and then the bullet and wad: and some use to cut that part of the cartredge away that lieth next to the touch-hole; but howsoever you cut the same in charging any peece with a cartredge, it behoveth you to prime the cartredge through with a skrewed or wreathed priming iron made sharp at the end, and then putting in your priming powder, you shall be sure not to faile of your purpose.

In giving fire to any great peece of Ordnance, as Cannon, Culvering, or such like, it is requisite that the Gunner thereto appointed, first see that the peece be well primed, laying a little powder about the touch-hole as a traine, and then to be nimble in giving fire, which as soone as he espieth to flame, he ought with quicknesse to retire back three or foure yards out of the danger of the reverse of the wheeles and carriage of the peece: for oftentimes it happeneth, that the wheele or axel-tree doth breake, and spoile the Gunner that giveth fire, not having agility to move himselfe from the danger of the same: yea, I did see a Gunner flame with the reverse of the wheele of a Culvering, which crushed his leg and thigh in peeces, who if he had had a care, and nimblenesse withall, might have escaped that misfortune. Also if the priming powder be dankish, or the cole of the match not cleare, the Gunner cannot spedily give fire; and therefore behoveth to fore-see it: or if he hold the lintstock in which his fired match is tied, long over the touch-hole, the violence of the flame issuing thereout is able to spoile him, or some thereabout, by throwing the lintstock or staffe which he gives fire with out of his hand. I have seen the lintstock and match blown out of the Gunners hand more then 80 yards from the peece, by the violent blast of the fire issuing out at the touch-hole of the peece, in giving fire to the same. And it is to be noted, that the wider ỳ touch hole of ỳ peece is, the greater flame doth issue out thereat, wch causeth ỳ peece to work lesse effect then she would, having a lesser touch-hole.

Any peece of Ordnence truly disparted, shoting at any mark in a streight line from the center of the hollow concave of the peece, and within point blank, shall strike so much under the center of the said mark (being laid iust against the midst of the said mark) as the visuall distance is from the top of the said disparture to the concave or cilinder of the peece.

To make a perfect shot at any mark, whether the same be at point blank, or at any degree ascending or descending: coyne your Peece so that the center of your eye in ayming lie close to the superficies of the middle part of the metall at the breech: and if the mark be at point blank, and the Peece truly disparted, and the visuall line so aimed (passing by the top of the said disparture) cut the center of the mark, then shall the bullet light so much under the center of the mark as is betwen the concave of the peece and the top of the disparture, if the wind alter not the bullet in his motion. And if the mark be further then the Peece will reach with her metalls, then must you elevate the Peece mouth so many degrees as will reach the same, first laying the Peece straight against the said mark: and whether the mark be point blank, above point blank, or under point blank, if you fix your eye in aiming above the levell light at the breech, the visuall line passing by the extreame or top of the levell light at the mouth of the Peece, will cut under the mark, and will cut or divide the supposed line in which the bullet flieth before it come to the mark, which bullet will light above the mark: or fixing your eye lower then you ought at the breech, the visuall line extending it self will cut above the mark, and never touch the line in which the bullet flieth.

Any Peece of Ordnance made hot with often shoting, being coled with water or vinegar, or other liquor, and presently after re charged again, will not convey the bullet so farre, as suffering the metall to cole of it selfe. And any Peece discharged divers times and not sponged and cleansed, the said Peece will not do such effect as being sponged every time presently after she is discharged.

If the trunions of any great Peece of Ordnance, as Cannon or Culvering be placed too neare the mouth, then the Peece will be so weighty at the breech, that she will require the aid of two or three Gunners to raise up the same with levers, that she may be brought to her mark: therefore to raise the same with one mans strength, so farre as another may coyne the Peece to shot at any mark assigned, lay some small coyne or peece of timber cut wedgewise on the side of the stock or carriage of the Peece, that may reach in heigth within two or three inches of the lowest part of the metall of the breech of the Peece, and putting in your leaver or handspike as neare the end of the breech as you can, betwen the said peece of timber and the metall of the Peece, you may raise the Peece at your pleasure, so as another may coyne the same to lay her to any mark assigned: and the longer your leaver is, and the least part of the end thereof that you put under the Peece, the more weight a great deale you shall raise up. Also by thrusting a strong lever into the mouth of the Peece,

weighing

weighing the same downe at the furthest end thereof, you shall weigh or raise up a weight; and the longer the leaver is, the more weight shall you counterpoise.

If being in service, you are like to leese your Ordnance, and would rather breake or burst the same in peeces then the enemy should have advantage thereof, you may easily burst any Peece with her common charge of powder, or with lesse powder then her common charge, as thus: after you have put home your powder, make a close wad as hard as ever you can thrust in after the same, and then take an iron bullet halfe an inch or more lower then the diameter of the concave of the peece, and put the same home close to the said wad, and under the said bullet drive in a wedge or taper peece of iron of fourteen or sixteene inches in length, made smooth and small at the one end, and great at the other, almost the height of the bullet, and giving fire with a traine, the bullet will run upon the same wedge and having no passage by reason the said wedge doth stop the way thereof, the Peece perforce must breake in peeces: or you may burst any peece with her common charge in powder at any part thereof, in thrusting her mouth into water to that part you would have broken, and giving fire by some traine, the Peece will burst at that part without the superfices of the water. The like may be done as some hold opinion in thrusting the Peece mouth into a hole made three or foure foot deep into the earth, ramming the earth close about the same, so as no ayre passe out at the peece mouth: or laying the peece upon the ground upon some Peeces of timber laid under the forepart and hinder part thereof, and making a hollow place under the midst thereof, make therein a good fire, and with a paire of bellowes make the Peece thorow hot, and with a sledge or great hammer striking the Peece in the midst, the middle part of the Peece lying hollow, you may easily breake the same.

If you would foretell whether any Peece of Ordnance will shoot short or over any mark appointed, standing on any side of and from the same Peece, and not beholding the visuall line how the Peece is laid to the mark, by having tryed and seene the fall of the bullet, the first shot is an easie matter to shew whether the said Peece shall shoot short or over any other time, being loaden every time alike (as thus:) before the Peece be discharged the first time, set up a Javeling, Halbard, or any streight staffe directly before the mouth of the Peece, and on the same make a privie mark hard by the upper or highest part of the metall, and when the Peece is brought to the same platforme againe and laid to her mark, and high her length given her to reach the mark, before the Gunner give fire, set up the staffe again in the same place, or cause another to set the same up, and if the highest part of the metall at the Peece mouth be elevated above the said mark on the staffe (which you may espy a pretty distance from the Peece) then the said Peece will out-shoot the first shot: but if the upper part of the metall at the mouth be under the said mark on the staffe, then the Peece will shoot short of the other shot, being loaden with one like quantity of Powder and bullet.

If you would annoy the enemy, and can come to ſerve under them out of ſuſpition, and would poyſon their Ordnance or any peece thereof, ſo as the ſame ſhould not readily bee made to ſhot, watch a fit time, and poure a little hot Oyle thorow a ſmall tunnell into the touch-hole of the Peece, the Peece mouth a little imbaſed, or raiſing her mouth a little, poure in a little water or other liquor thereat, the which will ſoak thorow the wad into the Powder, ſo as the ſame will not fire, or elſe cloying up the touch-hole with nailes driven to the head, you may for a ſeaſon hinder the ſame from ſhoting, to the great annoyance of the enemy and furtherance of your friends, they having ſome privie warning thereof: the chiefe and readieſt way if a Peece be poyſoned, is, to draw the ſame, or if the touch-hole be cloyed up, is to make a train in at the Peece mouth to the chamber where her loading lyeth, and ſo recharging her it will blow out the ſame, or elſe it muſt perforce be drilled out.

The Platforme wherron your Ordnance is planted in ſervice, ought to be flored with ſtrong wodden planks of timber, or paved with broad ſmoth ſtones, laid cloſe together, ne higher in one place then in another, but flat and plain on the ſuperfices thereof, for the wheeles and carriage to make their revers upon, for if the like platforme be not made, the wheeles in often reverſing will ſo ſink into the ground, that the Peeces without great trouble and more ſtrength of men will not be brought to their right platform again; eſpecially after moiſt weather, the ground being wet before: and the Peece ſhall ſometimes ſhot amiſſe, by reaſon the one wheele will ſometimes ſink deeper then the other. The platform behind the carriage would be made a little higher then before; ſo ſhall the Gunners with more eaſe a great deal bring the Peece to her true platform after ſhe is reverſed.

If you would ſee whether the Peece you are to ſerve with, be cleane without flawes, hony combs, or cracks, then turning her mouth towards the Sun, being unloaden, with a looking glaſſe you may caſt the beam of the Sun into the concave of the Peece: or if the Sun do not ſhine, with a lighted candle put on the end of a cloven ſtick you may alſo ſee the ſame: but if you feare that ſhe hath ſome cracks, blow her with a quarter or halfe of her loading in powder, and preſently ſtop her mouth with ſome cloth or other thing, that no ſmoak iſſue out, cauſing another to do the like at the touch-hole: and if there be any crack in the Peece, the ſmoak will iſſue out thereat. Alſo you may perceive if a Peece be without crack or flawes, in ſtriking upon the ſame with ſome iron tole, and if the peece be without crack ſhe will have a clear and ſharp ſound being unloaden, otherwiſe ſhe will have a harſh or dull ſound.

Any Gunner skilfull and experienced in the Art, may diſpart any great Peece ſeven ſeverall wayes, but the readieſt and eaſieſt way is to thruſt your priming iron into the touch-hole of the Peece, down to the loweſt part of the concave of the Peece, and with your knife make a mark on the ſaid priming iron, tight with the height of the utmoſt part or higheſt part of the metall there. Then draw out the ſame priming iron, ſetting the ſame upright at the mouth of the Peece, ſo as the loweſt end of the

the ſaid priming iron touch the loweſt part of the concave there alſo, and hard by the upper part of the metall at the mouth of the peece with your knife make another mark on the ſaid priming iron, the diſtance betwen thoſe two marks is the true diſparture of that peece.

To any one or more Peeces of Ordnance of like length and heigth, that ſhooteth one quantity of one like powder and bullet, may be made a preciſe table of randons: but a thing unpoſſible to make one perfect table of randons to ſeverall peeces of contrary length and heigth, diſcharged with one like or unlike powder and bullet, although divers authors have affirmed the ſame may be done, and have given out rules thereof: for the variable length of the peeces, the differing weights of the bullets, and the ſundry forces of divers kinds of powder, muſt and will alter in each of theſe caſes.

By experimenting divers ſhots out of any one or more peeces of Ordnance, of like length and heigth, diſcharged with one quantity of one like powder and bullet, I could artificially deſcribe how to make an inſtrument, which ſet upon the breech of the peece, the uſuall line thereof ſhould ſhew what length the ſaid peece requireth to reach any mark within the utmoſt random of the ſaid peece, as alſo ſhould ſhew the number of degrees the ſaid peece is elevated at, and how farre the ſaid peece would convey her bullet at any degree of the random, or what diſtance any mark is different from the peece, and how much higher or lower the ſaid mark is then the point blank of the ſaid Peece, the ſaid Peece loaden at every time with one like quantity of one like powder, wad and bullet, and of like temper: but forasmuch as the ſame will not hold in all peeces of contrary length and heigth, neither in any one peece of Ordnance diſcharged with her due loading of divers kinds of powder, it were a thing not convenient to ſhew the reaſons thereof, for that the ſame requireth a long diſcourſe, and would be to no great purpoſe, unleſſe the ſame might be a generall rule for all peeces of what length and heigth ſoever.

You may diſcharge any Peece of Ordnance by the beame of the Sun, a pretty diſtance from the ſame, the Sun bright ſhining, and the day clear and hot, in taking a broad bright baſon, ſetting the ſame ſo on the ſide of the carriage of the Peece againſt the touch-hole, that it may ſtrike the reflex of the Sun-beam back upon a train of fine powder laid upon and about the touch-hole of the Peece, in the midſt whereof lay a little fine lint dipped in molten brimſtone, and on the ſame a chryſtall ſtone: and ſtanding thirty or forty yards from the ſame (or further if you think good) by the aide of three or foure glaſſes well ſteeled, you may caſt the beam of the Sun directly againſt the center of the baſon, which will ſo multiply the heat, that it will preſently fire the train, and ſo diſcharge the Peece. Or you may give fire to any Peece of Ordnance with a burning glaſſe, but then you muſt be ware to the Peece which will be perillous, for feare of the reverſe of the wheele, except you make a train, and ſo drawing the beam of the Sunne into a point like a pin head thorow the center of the Glaſſe, you ſhall ſo multiply the heat that it will preſently give

fire to the Peece. I read that Archimedes by his skill in Geometry, and in the Art perspective, did from off the wals of Siracusa (the City being besieged by the Romans) fire their Navy riding in the road without, only by the aid of glasses; as also divers of our own Countreymen by the aid of glasses have experimented many notable and strange conclusions to their everlasting fame.

You may also with a quart or pottle of any liquor, as wine, water, ale, or beere, discharge any peece of Ordnance, in putting into the touch-hole of the peece the end of a peece of match of a yard or five quarters long, well soaked in molten brimstone, the Peece being well primed; and setting or making fast to the side of the carriage of the peece, any little half firkin or woodden vessell that will hold a gallon or pottle of liquor, filling the same half full of lime-stone new burnt and unquenched, and take the lightest and whitest stones you can finde (for thole are best burnt:) then take three or foure of those stones, and beat the same into fine powder, and mix with three or foure handfuls of the same, as much powder and brimstone beaten very fine, laying the same amidst the vessel upon the stones, rowling the other end of the match in that receipt, and then fill up the vessell with other like stones, pouring upon the same as much liquor aforesaid as would fill half the tub; the which will melt the stones into dust, and drink up all the liquor, and with the heat thereof will presently fire the brimstone, which kindling the match will discharge y peece: and if you make the said liquor seething hot, and poure it into the vessell, it will so worke therein, that if the vessel be not all the better girded, it will burst it in peeces.

If in service, or at any other time, you have occasion to shot divers shots in one or mo peeces, the day being very windy, so that it bloweth away y priming powder laid about y touch-hole of y peece, to prevent y inconvenience, if you take a little tough clay, working the same well in your hand, & laying y same upon y metall of y peece on y windy side in manner of ½ a circle, 1 or 2 inches from y touch-hole about 1 inch height, it will hinder the wind from blowing the priming powder away, so that you may give fire at pleasure.

Any peece of Ordnance being discharged in y night, the report or roare thereof will be heard further then if the had been discharged in the day, the weather of like calmnesse; and the report will sound further down y wind then against the same, and further on the sea then on the land, the ayre quiet and the sea calme. Also if you make a hole in the ground 5 or 6 inches deep and lay your eare close thereto, you shall heare the report of any peece of Ordnance discharged from farre more perfectly, then standing or walking: by experience it hath been often tried, that the sound of the Cannons discharged at the siege of divers holds, hath been heard very near 40 miles

Some Gunners hold opinion, that the reverse of any peece of Ordnance discharged, is not before y fire be clean expulsed out of y concave of the peece into the open ayre, but therein they erre, for experience sheweth that the peece & carriage beginneth to recoil in y moment allon as ever y powder

fired

fired within the peece, begineth to thrust it self out, the violent expulsive motion whereof striving forward, causeth the peece to recoyl, but the roar or report of ỹ peece discharged, is not before the fire be expulsed out of the peece. Also some hold opinion, that the force of the fire departing from the peece, causeth the metall to quiver or shake; and to assure themselves, they have for triall clapt to the bottom of a glasse a little quantity of wer or pitch, and filling the glasse with water, set the same upon the highest part of the metall, about the middle of the peece, and because the same hath bin ken in shivers or fallen, they think their opinion is strong: but my opinion is contrary, for if the metall of the peece at her discharge do any whit q iver or shake, the peece would either burst in shivers or rent it self; for I hold that it is the very aire or violent blast proceeding from the fire, either out of the mouth of the peece or touch-hole or both, and wi hall the sudden reverse of the peece that doth cause the thing so set upon the upper face of the metall to burst or fall off: and for the better triall hereof, I asked the opinion of a souldier, who for a trespasse committed was entoyned to ride the Cannon, who confidently affirmed, he could perceive no quivering of the metall of the peece, but that the aire which issued out of the mouth and touch hole of the peece did somewhat astonish and shake him.

A ball or billet of wild-fire shot out of a Chamber or Morter peece, having one or mo vents made upon any one part thereof to kindle the ball, although for a little motion the said vents burn from you in the range thereof, by reason they are first fired, and stand neareſt to the peece mouth before the delivery thereof, yet for the greater part of the range the ball will turn & burn with the said vents towards you, as by experimenting the same you may see; for reason teacheth, that any solid thing violently driven, fleeth with ỹ part foremost that is most ponderous & weighty, which in this case must nedes be ỹ part of the ball unburnt, or wi not vented.

A ball of wild-fire discharged out of any peece of Ordnance, having but one vent, the swifter ỹ the receit is in burning the further it will range, the peece being presently discharged as the ball is fired: and the slower the receit is, the lesse distance will the renge be; and any ball having but one vent will range further and burne longer then having divers vents.

A ball of wild fire made to burn in the water, being fired and thrown therein, that part wil appear first above the water that is lightest (to wit) that part wherein ỹ vent is, the which ball wil not burn perfectly above the superficies of ỹ water, until ỹ ⅓ thereof be burnt & emptied, & so being filled with aire doth cause the other part to swim & burn above the water.

A ball of wild-fire made never so artificially, shot out of a Morter, Chamber, or other great peece of Ordnance, the peece having her full loading in powder, that is used to give her in shooting a bullet of metall, wil cause the said ball to burst in peeces, and therefore the said peece must be loaden with a proportionall charge in power to the weight of the ball, which wil not be above ⅓ the weight of the ordinary charge used to shoot a ball of metall.

A ball of wild-fire discharged out of any peece of great Ordnance, being vented

vented or bored thorow crosse-wise, and primed full of powder to take fire, although the flame of the fire in the burning of the said ball issue out at every end of the said vents, that is foure severall wayes, yet in the motion or range therof, the greatest part of the flame & fire will issue out but at 1 or at 2 vents at the most, which will be those vents in that part of the ball that is towards the Peece, for the violent moving of the ball thorow the ayre, doth cause the flame to shew it self, and to burn most on the contrary part against which it flyeth: the which flame will shew it self as it were a taile, or traine following the ball in his motion. And it is to be considered, that in shooting any Peece of Ordnance with a fire-ball, the Peece would bee loaden with lesse then half her ordinary charge in powder, or with the one half at the most, that is with one ladle full of powder, the which put gently home with the tampion on the end of your rammer staffe, put in the ball close to the powder, priming the same wel before you put it in, and after the ball put in a handful of powder close to the ball, so shall you be sure the same will take fire, and not burst in the flight or range being well wadded and marted.

The receits wherewith balls of wild-fire or other fire-works are made being slow, may be made more stronger and to burne more furiously, by adding a little bruised powder to the receits, working the same well together: and any fire-work whose receits be too forcible in burning, may be made more slow, by adding a quantity of some liquid receit thereunto.

A ball or bullet of wild-fire discharged out of any Peece of Ordnance in a cleer day, at any mark within the reach of the peece, cannot be discerned in his range, nor seen to burn before it light on the ground. And any ball of fire-work discharged out of any Peece of Ordnance at any mark in the dark night, may be perceived by the eye all the range thereof: and the more darker the night is that the same is so discharged, the better you may discern the same: but in the beginning of the range, the eye is not able to discern it so perfectly as in the latter part therof, neither doth the ball burn so forcibly, nor give such light in his swift motion (that is in the first part of the range) as in the latter part of his motion, when it declineth towards the ground.

If you take Arsnick and Sulphur of each like quantity, and beat the same very fine, and then boile the same in a covered pot, and then kindle the same with a candle, letting no other light be seen, the standers about the same will seem monstrous strange one to another.

Or if you take Aqua composita and salt, and pound the same together and fire the same in the dark where no other light may be seen, the beholders will seem as they were dead.

I read in Albertus Magnus, and divers other such Authors, how to make strange lights: such as would practise the same may have recourse to their works.

DEVISES

DEVISES

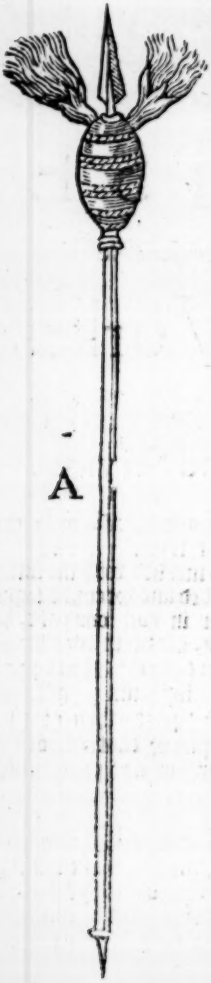
of certaine ſerviceable

Fire-Workes,

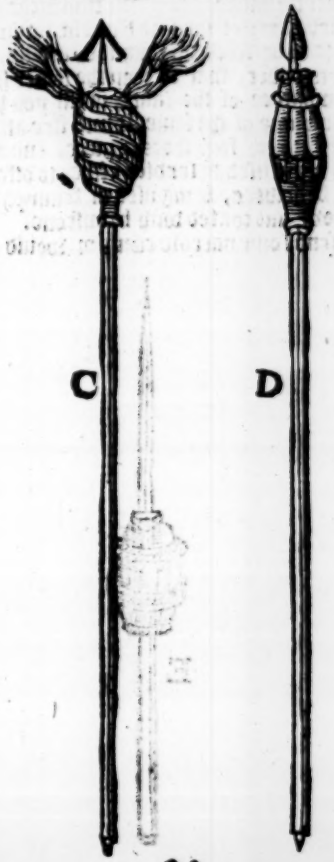
Very neceſſary to bee uſed both for Sea and Land Services.

TO arme Pikes to defend a ſhip or a breach, or to enter the ſame, take ſtrong canbas, the which cut, ſewed, and tied hard on the Pike with marlin cord, as the draught marked with the letter A ſheweth: fill the ſame with this receit compounded and wrought together (to wit) Powder bruiſed eight parts, Peter in roch one part, Peter in meale one part, Sulphur in meale two parts, Rozin in roch three parts, Turpentine one part, Linſeed oyle one part. Verdegreſe ½ part, Bole Armoniack ½ part, Bay Salt ½ part, Colophonia ½ part, and if you think good you may put thereto of Arſnick ½ part; then coat the ſame over with this liquid mixture molten in a pan or coating pot (to wit) Pitch four parts, Linſeed oyle one part, Turpentine ½ part, Sulphur one part, Tarre ½ part, Tallow one part. And as ſone as this is cold, bore two holes in each of the ſame an inch deep with a ſharp iron or bodkin, filling the ſame with fine bruiſed Powder, putting in every hole a little ſtick of two or three inches length, which are to be taken out when you would fire the ſame: this compoſition will burne like tow. If you pleaſe you may make faſt to the ſame receit on your Pike, certaine light Pipes or canes of tinn or braſſe of ſix or ſeven inches length, being ½ inch or Caliver bore, as the draught B ſheweth, placing the touch-hole thereof cloſe to the canbas, boring the ſaid canbas through, and priming the ſame with fine Powder, and upon the ſame paſte a little paper, and then coat the

ſame over as aboue is ſaid, the which charged with Powder and bullet will doe great execution in a ſtrong, either to offend or defend.



You may arme a Dart, a Jabelin, Partizan, or such like weapon, to do excellent good service, being in the hand of a valiant souldier, as you see the figure C, the which may be filled with the self like receit as is taught to arme Pikes with wild-fire, which would be a very good weapon to throw into the sides or sailes of ships; or you may place upon the staffe of your Jabelin certaine Pistol barrels of one length, about ten or twelve inches, letting the same into the wood round about the staffe a little, as you put a Pistol barrel into the stock, as the draught D sheweth, which staffe must have substance at the one end whereto you may naile the same barrels fast at the breech, & about the midst of the same put over



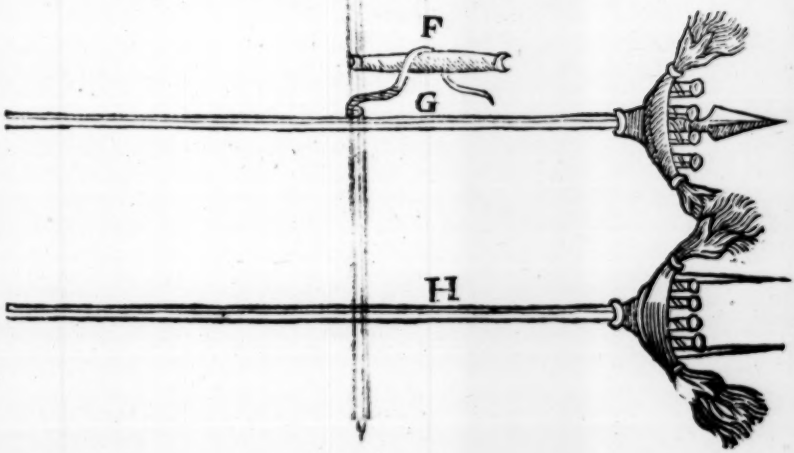
a hoop of iron as close as ever you can, the which is to be charged in this order following, viz. first charge every barrell with two inches of powder, after put in a bullet a little lower then the bore of the same peece, then take of this slow receit following (to wit) bruised Powder four parts, Saltpeter in meal one part, Linseed oyle one part, Brimston finely beaten one part, Varnish one part, and of willow or hazell cole moistened with a little vinegar one part; all these would be well wrought together with the hand in some wooden vessel, till you feele that it will cling together, of which you must put in after the bullet two inches, and thrust the same together with a rammer stick; then againe put in other two inches of Powder, and after a bullet, and lastly two inches of this slow receit, untill you have filled every of the said barrels within half an inch of the mouth, the which is to be filled up with the said slow receit and powder bruised and mixed together, that it may the sooner fire: this done, binde a paper over the mouthes of the same, untill you would occupy them, and giving fire to any one of the same, it will fire all the other, and every one will discharge three or four shots a piece, one after another, to the hurt of the enemy, being used in service either to offend or defend, and to the pleasure of the beholders, being used in triumph with bullets of receit rolled in fine tow, and coated with brimstone.

If you would defend some narrow rom, or would enter up a paire of

mixed

ſtaires, where you cannot weild a long weapon, you may make a logget whoſe ſtaffe ſhall be but three or foure foot long; arming the ſame with the like receit as I have ſhewed to arme Pikes, whereon you may place certaine Pipes of braſſe or iron charged as afore is taught; and if you will you may put into the end of the ſtaffe a Rapier blade with a ſkrew to take off and on at your pleaſure, as the draught E ſheweth.

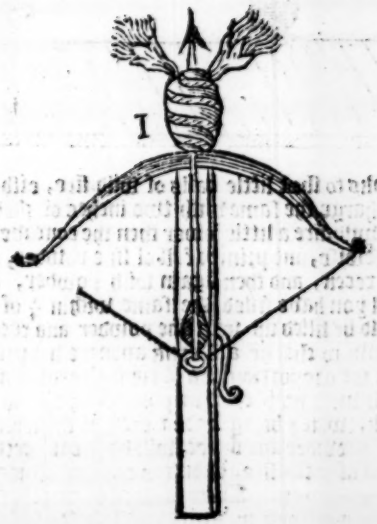
Alſo you may arme a Partezan, Jabelin, or Fork with fire-work, to offend or defend a breach, ſhip, or any place of defence, and to ſhot every of them ſeven or eight Piſtol or Caliver bullets, in nailing a plate of iron croſſe the Pike or point of the ſaid Jabelin, or between the grains of the Fork, piercing certaine holes through the ſame, unto which with a ſtrong wyer you may make faſt on either ſide ſo many pipes of iron of ſeven or eight inches length as you think convenient to fix upon either or any of the ſaid weapons; and charging the ſame with powder, bullet, and wad, you may cauſe the ſame to fire one after another, in filling a role of Canvas ſewed together, as the draught F ſheweth, with ſlow receit and coated as afore is taught; the which placed artificially upon the ſaid ſhort barrels or pipes, as the draught G. H. ſheweth, and primed with fine Powder directly againſt the touch-holes of the ſaid ſhort barrels, paſting a little paper over the ſame, firing the ſaid traines at both the ends, which as they burne ſhall ſtill diſcharge the ſhot peeces one after another, to the great god of the defendant.



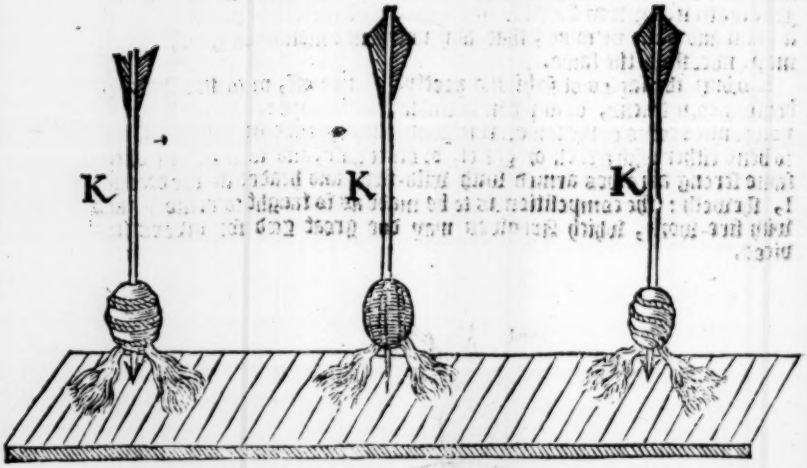
To offend or defend any narrow passage, or for divers other Military services, you may place upon the point of a Pike of any Halbard a device of fire-work, in manner as is taught to arme Pikes, made of the same like receit, and coated with the self like coating: And if you please you may make fast thereto half a dozen or more shot Pipes, like Pistoll barrels, of 7 or 8 inches length, loaden with Powder and bullet, as this Draught sheweth.

Or you may make a serviceable Halbard by which you may know the houre of the night, by viewing the North Star, and guards (commonly called the lesser Beare) which compasseth about the North Starre once every 24 houres, very necessary for all Leaders and Commanders of Military men, by placing upon the Bill or Axe of the Halbard a roundell divided into 24 equall divisions, and traced and drawn with an index or Pointer having a hole pierced thorow the center. The order how to make the instrument, as also how to find out any houre in any night that the said stars may be seen, you may learn in the 17 Chapter of the Art of Navigation, written by Martin Curtis, who sheweth the same in such a plain and easie manner, that any unlearned man having a sharp wit may understand the same.

To burn the sayles of Ships a pretty distance off, or to fire thatched houses, corn-stacks, or any combustable matter apt to burn, when as you cannot come to the same, it is good to make certain strong bowes, to bend either with a rack or gassel, or otherwise, and to shoot out of the same strong arrowes armed with wild-fire, and headed as the draught I, sheweth: the composition is to be made as is taught to arme Pikes with fire-work, which Arrowes may doe great good for divers services.



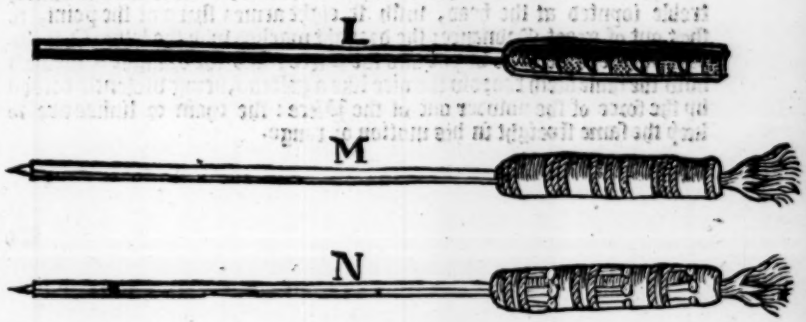
To burne Bridges, wooden gates, &c. or to doe divers other Military services, if you can come to annoint the same with some such liquid composition as I have shewed for the coating of fire-works, melting in the same a good quantity of bruised brimstone, and sticking in the same Arrowes of wild fire made in proportion as the draught K sheweth, the which may be made of the self like receits, as is taught to arme Pikes with fire-works, which will undoubtedly set the same a fire, for the receit is so forcible, that it will burn in the water.



To charge Trunks to shot little balls of wild-fire, either to offend or defend, you must charge the same with two inches of good powder, and then with a ball of wild-fire a little lower then the concave of the Trunk, bored thorow crosselwise, and primed full of fine powder, and lastly with two inches of slow receit, and then again with powder, and then a ball and so receit, untill you have filled the same within ¼ of an inch of the mouth, which would be filled up with fine powder and receit mired together. The order how to charge a Trunk appeareth by the draught L, draught M sheweth the proportion of a Trunk already charged and fired, and the draught N sheweth how certain pipes of brasse or iron may be placed on a Trunk, which being loaden each of them with a Pistoll or Caliber charge of powder and bullet, will do great execution.

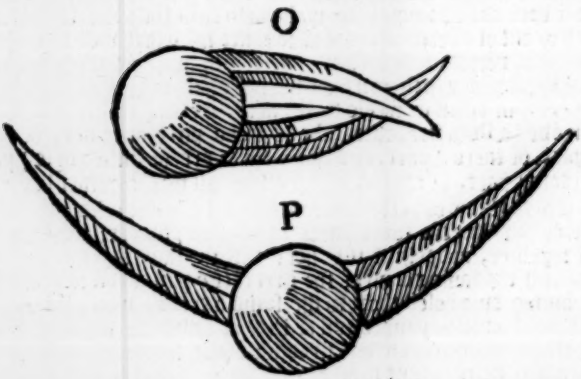
The bullet or ball of wild-fire, or button as some Gunners terme it, would be made in this manner. Take untwisted match, tow, or hempe, the which would be moistned in Aqua vitæ, or good saltpeter water, then take of brused powder six parts, of saltpeter one part, of brimstone finely

finely beaten one part, of cole made of light wood, moistened with a little linseed oyle and turpentine wrought together one part; then laying the tow or Ream abroad in thicknesse of the back of a knife, and as broad as a great Oister shell, put into the same as much of the receit as you can grasp together in your fist, and tying the same hard with packthread, coat the same over with molten brimstone, and when you would use the same, bore it thorow crosse wise with a bodkin, and fill the holes full of fine powder bruised. Or you may make bullets of wild fire to shot out of a Trunk or out of a peece of great Ordnance the which will be as hard as a stone, and needeth no coating, the which being a little burnt will cleave to any thing at which you shot the same, in taking of sulphur in meale six parts, of rozin in meale three parts, melting the same in some pot or pan over a slow fire, then take of stone pitch one part, of hard wax one part, of tarre ¼ part, of Aqua vitæ ¼ part, of linseed oyle ¼ part of verdegrease ½ part, of camphire ⅕ melting all these together likewise and stirre into the same of peter in meale two parts; and taking the same from the fire, put therein foure parts of bruised powder, working the same well together, and whilst it is hot thrust the same together in your hands, and roll the same round of the greatnesse you mean to make the balls of, boring two holes thorow the same a crosse, which when you would occupie, would be primed full of bruised powder: these balls being cold will grow very hard, and fired will burn furiously, not diminishing in quantity being burnt to ashes, the ashes whereof will kindle an oaken board.



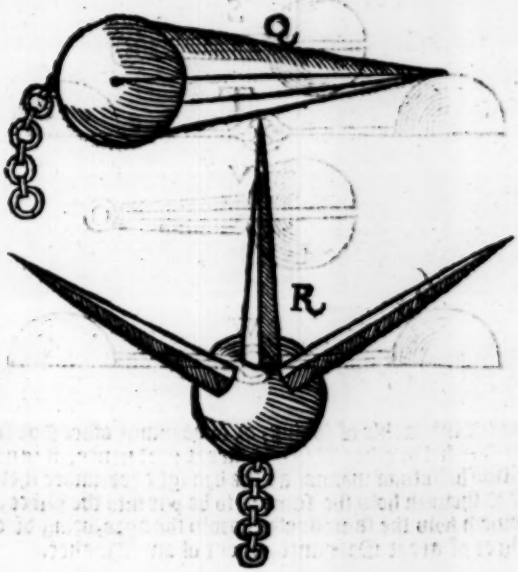
To cut the cables, shrouds of masts of Ships, a good pretty distance off, being in sea service, there is devised out of great Ordnance to shot certain bullets that shall open and shut with a joynt in the head, as you see a paire of compasses, the armes or legges whereof are made in pro-

portion to the blade of a knife, taperwise, and bowing sharp towards the point as the draught hereunder sheweth, where the draught O sheweth how the same is to be put into the Peece after the powder and wad, and the draught P sheweth how the same in his violent motion flyeth thorow the ayre like a sithe, being shot out of any Peece of great Ordnance.

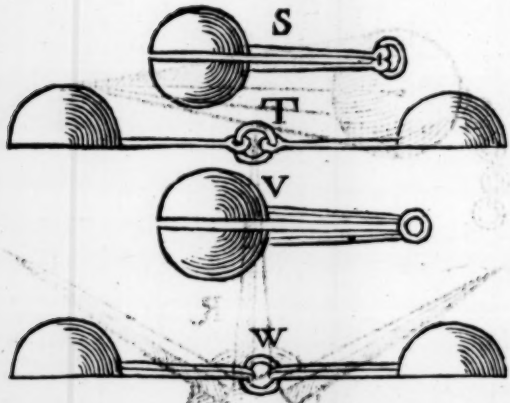


There is also devised for like service afore said, another kind of bullet, treble joynted at the head, with streight armes sharp at the point, to shot out of great Ordnance: the draught marked with the letter Q sheweth how the same is to be put into the Peece; and the draught R sheweth how the same flieth thorow the aire like a galtrop, being violently driven by the force of the powder out of the Peece: the chain or linkes are to keep the same streight in his motion or range.

To



To cut the tackle and shrouds of ships, it is good to cast halfe bullets of iron or lead; unto every of which make fast a barre of iron, wrought either three square or foure square, of the greatnesse of a mans finger, al cut fourteen or fifteen inches length, with a loop at the end, unto which a ring of iron is to be put, that the same may close and shut as the draught S sheweth, shewing also how you must put the same into the peece: and the draught T sheweth how the same breaketh in his moving through the ayre. Of to the said halfe bullets you may make barres in proportion of a knife blade, with a round joynt at the end to open and shut, the which kind of bullets may al well be made to shot out of Muskets as out of great Ordnance, to the great annoy of the enemy, especially in sea-service, as the figure V. W. sheweth.



Alſo to cut the tackle of Ships, or to do many other good ſervices, either with Musket or other Péce of great Ordnance, it is good to chaine together two bullets in manner as the draught hereunder sheweth, where the letter X sheweth how the same is to be put into the Péce, and the letter Y sheweth how the same flyeth thorow the ayre, being discharged out of any Péce of great Ordnance, or out of any Musket.

Alſo for like purpoſe aforeſaid, if you take a ſmall iron chaine with handſome links, rolling the ſame round together, ſo as the ſame may goe eaſily into the Péce cloſe down to the wad, the ſame being again diſ-

char-

charged out of the Peece, will spread it self as the draught marked with the letter Z sheweth.

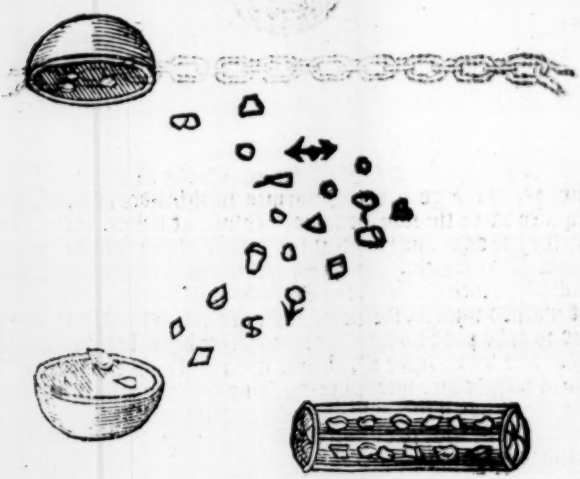
Z

There is also used to cut the Halls or shrouds of ships, or to boudge the same, &c. to charge great Ordnance with bullets of iron, having a great square barre thorow the same, of two foot length or thereabouts, sharp at the one end, and round at the other, about half the diameter of the cilinder of the Peece, and on the midst thereof a bullet about ¼ part of an inch lower then the height of the hollow cilinder of the Peece, as the draught marked with A, sheweth, these are called crosse-barres: when the same is to be put into the Peece, the Peece being loaden with her due of powder and wad, some use to put upon the small end thereof a good quantity of old Ream, wrapping the same fast about with marlin cord, and some use to put a tampion of wood upon the end thereof, and some wrap a piece of an old sattle or other old cloth fast upon the end of the bar, and so discharge the same.

A

Being in sea-service, if the enemy will needs board you, and that you intend not to yeeld, it is necessary to have in store and readinesse divers hollow bullets, made of two plates of iron or other metall, so as the one may close round upon the other like a box, the which filled with pebble

stones, square peces of iron called dice shot, Musket bullets, and such like, and discharged out of a murdering Peece will doe wonderfull hurt: behold the draught ensuing. Or if you fill cases of wood, made like unto a Lanthern full of pebble stones, dice shot, Musket bullets, peces of iron, or such like, discharging the same out of any Peece of great Ordnance (especially out of a murdering Peece) will doe great execution against such as are to enter a breach, a bridge, a gate, a ship, &c.



If you be to enter a ship or other place where you feare there is some train laid to blow you up, you may prevent the same by making certain purses of canvas filled halfe full of good corn powder, and with 8 or 10 fiery bullets of an inch or an inch and half in height, such as I have taught to port in trunks, and filling the other part of the purse with such slow receit as there is also taught, you may when you think good (the receit being well fired) throw the same from you, which will burst in pieces after the lighting on the ground, and disperse the said inclosed bullets here and there, which bullets will burn furiously, and if there be any train of powder laid neere, will presently fire the same. The said purses are very good to throw out of hand, or may be shot out of a morter peece amongst men in battell array, to disorder them, or into a Town: the draught B sheweth how to fill the purses here is taught, and the letter C sheweth the proportion of it, being made up, filled and coated over.

To shot a ball of wild fire out of a Cannon, Culverin, or other great péece of Ordnance in time of service, amongst the enemies a farre off, or into Towns, or in triumphs before Princes or great personages, take strong canvas doubled, and cut out a piece as round as the circumference of a circle, iust the height of the diameter of the concave of the Péece out of which it is to be shot, the which sewed sure round about all saving one inch, fill the same full of this receit following (to wit) powder bruised 8 parts, Peter meale 2 parts, Peter roch 1 part, rozin roch like pepper cornes 2 parts, turpentine half a part, Linsed oyle 1 part, Sulphur meale 1 part, Sulphur roch 1 part, bole armoniack a third part, Verdegrease a fourth part, Colophonia a sirth part. All these things mixed in a tray or some such like wooden vessell, and wrought well together with the hand, fill the said ball therewith as hard as you can; then sewing up the hole and woolling and marling the same well, coat the same over with molten brimstone, and with a sharp iron a little greater then a bodkin, bore 2 or 3 holes crosse thorow the same ball, priming the same full of fine bruised Powder; and when you would shot the same, load the Péece but with half the quantity of her common charge in Powder, and after put in the ball close to the said Powder, and after put in a good handfull of powder close to the ball with the taunpion on the end of your rammer staffe, the Péece mounted about 12 or 14 degrées will cause the ball to range above 24 score paces. If you would have the ball to make a pleasant range, mount the Péece above 30 degrées, and if the transome of the carriage will not suffer it, then you may dip the lower end of the carriage into a hole made in the earth for the purpose, the draught D sheweth the proportion of such a bullet.

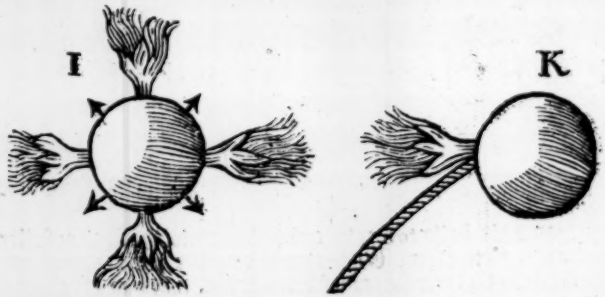
To

To ſhoot a ball of wild-fire out of a Chamber or Morter peece, you muſt charge the peece with Powder according to the proportion of her chamber, and quantity of the ball or bullet that ſhe is to ſhoot, and according to the diſtance the ball is to range, and then take a cloſe wad as hard as you can put home to the Powder, and after put in the ſaid ball, firſt making 3 or 4 vents therein within the compaſſe of a ſhilling, an inch or two inches deep with a bodkin, priming the ſame with fine beaten powder, and be ware when you put the ſame into the Peece, that the vents be uppermoſt next to the mouth of the peece, juſt in the center or midſt of the concave thereof, then take a piece of Gun-match, or a little hay twiſted with your hand, and after the ball is in the Peece as is ſaid, put the ſame round about the circumference of the bullet, and with a ſmall wooden wedge beat the ſame cloſe round about the ball, between the ſaid ball and the metall of the peece, ſo as no powder fall into the peece, whereby the ſame might be diſcharged before the ſaid ball were well kindled with the traine which you are to make at the mouth of the peece. This done, prime the Peece well at the touch-hole, laying a little powder on ſome broad ſtone as a traine to fire the ſame readily, covering the ſame with ſome cloth til the ball be well fired, leſt ſom ſpark iſſuing from the ball, fire the peece too ſoon. And when you ſee the ball is well kindled, take away the cloth, and give fire to the traine at the touch-hole, and ſo ſhooting the ſame amongſt men in battel array, or into a Town amongſt thatched houſes, or corn-ſtacks, this kind of fire-work will do excellent good ſervice: the letter E ſheweth the proportion of ſuch a bullet to be ſhot out of a Chamber or Morter peece; but if you be to ſhoot out of your Morter or Chamber peece bullets of ſtone or of metall into ſome Hold or Town, then you need do no more but only loading ỳ peece with her due of powder wad & bullet, giving fire to ỳ traine at ỳ touchhole, & giving ỳ peece her due length, ſhe will perform your wiſhed deſire.

To make balls of wild-fire to ſhot out of a Chamber or Morter Peece, that being recharged ſhall ſtick in wodden gates, ſhips ſides, or ſuch like: make of thoſe balls I have taught to ſhot out of a Cannon or Culvering, the which filled as full and as hard as you can, with the like receit as there is taught, and wolled well, and coated over, make certaine peeces of iron ſharp at the point of two inches length, with a skrew of three quarters of an inch long at the one end to skrew into the ball, and hard by the ſame a ioint with a ſhoulder, that you may when you pleaſe, put the other end together cloſe to the utter ſide of the ball; the which nailes or ſharp peeces of iron skrewed into the ſhoulder into the ball (the ball being made ſomething lower then the concave of the peece) being diſcharged out of the Peece, will ſtick in any ſoft obiect, as wood, or ſuch like; for the forcible motion of the bullet or ball will thruſt the ſaid peeces of iron ſtiffe out in their ioynts, ſo that lighting upon any reſiſting obiect (except ſtone) will ſtick in the ſame: the draught following noted with F. ſheweth how the ſame is to be put into the Peece, and the letter G. ſheweth how the ioynts do ſtretch themſelves in the violent motion thereof, diſcharged out of a Chamber or Morter Peece.

Or you may make balls to throw out of hand into the ſides or ſailes of ſhips of the receit aforeſaid, in skrewing into the ball round about the utter ſide thereof, certaine peeces of iron, made ſharp at the ends, like an Adders tongue, as the draught H hereunder ſheweth.

You may also make another kinde of fire-ball that shall burne furiously, and give a great light, that shall stick in any resisting object that you are to throw the same into, in taking three or foure peeces of iron of like length, made sharp at the point, letting the one into the other in the midst so as the one may crosse the other iustly, and taking of Goose grease or Swines grease one part, of Tarre ½ part, of Pitch two parts, of Aqua vitæ ½ part, of Linseed oyle one part, of Turpentine one part, of Verdegreese ¼ part, of Wax ½ part, of Gumme ½ part, of Saltpeter meale one part, of Sulphur meale one part; melt all these together over a slow fire, and in that liquid mixture dip a good quantity of tow and linnen rags, and after rub the same well in bruised powder, the which rolled hard round about the peeces of iron aforesaid, binde the same about with small wyer or pack-thread; and when you would occupy the same, bore two holes crosse through the same, filling the same with bruised powder, the draught I sheweth the proportion of such a ball as here is spoken of. This kinde of fire-ball may be made to shot out of great Ordenance, in making the same round as above is said, without the peeces of iron: or you may make of these balls to throw with hand amongst men in battell ray, or into ships, or you may use the same in a triumph for pleasure, in tying a cord of three quarters long thereunto, as the letter K sheweth.



To make a fire-ball to burne in the water, take Powder bruised ten parts, Peter in meale two parts, Peter roch one part, Sulphur meale three parts, Rozin roch three parts, Turpentine one part, Linseed oyle one part, Camphire ½ part, Arsnick ½ part, Verdegreese ½ part, Bole Armoniack ½ part, cornes of Bay salt ½ part, filings of iron ½ part, Quick-silver ½ part. All these things being well wrought together with the hand in some wooden vessel, double a peece of canvas, and cut out of the same a round peece of three inches, or three inches and a half diameter, which being well sewed fill the same with this receit, and binding the same strongly about with pack-thread, and coating the same over with molten Pitch, or with the mixture taught to coat Pikes of wild-fire,

make

make therein but one vent of an inch deep, priming therein fine bruſed Powder, and put into the hole a little ſtick of two inches length, which when you would occupy you may take out, and letting the ſame burne awhile in your hand, caſt the ball into ſome hogſhead full of water, or into a river or pond, and the ſame will come up to the ſuperficies of the water, and burn furiouſly; the draught hereunder ſheweth the manner thereof.

Or you may make a ball of wild-fire to burne in the water in this manner: take brimſtone in meale two parts, and melt the ſame over a ſlow fire, and therein put of ſaltpeter in meal one part, of gum one third part, of wax one fourth part; and taking this compound from the fire, ſtirre into the ſame of bruſed Powder three parts, working the ſame well together, moiſtning the ſame with a little oyle of linſeed, or Aqua vitæ, and putting this receit into a peece of canvas ſewed up round and marled and coated over as before is taught, boring a hole therein of an inch deep, and priming the ſame full of bruſed Powder, this ball will burne in the water whenſoever you would uſe the ſame, but it is not of ſuch force as the ball filled with the other mixture. You may make balls of this receit to ſhoot out of a Morter peece, boring through the ſame two holes, the one croſſing the other, or boring three holes in the ſame into the center or midſt of the ball, as the draught L ſheweth.

It is good either for ſervice on ſea to burne the ſailes of ſhips, or on the land for diſordering men in battell ray being neare, or for divers other military ſervices, to have certaine ſhort muskets of an inch, or very neare an inch bore, out of which you may ſhot either chained bullets, or half a ſcore piſtol bulles, or half a dozen harquebuz bullets at one ſhot: or you may ſhot out of the ſame fire arrowes made with ſtrong ſhafts, fethered with horne, or with common fethers, glewed and bound on with thred: when you are to ſhot a fire arrow out of any of theſe peeces, you muſt not give the Peece her full loading of powder, but rather $\frac{2}{3}$ parts thereof, and then put in a cloſe wad after the powder, and put in the arrow cloſe to the ſaid wad, firing the ſame at the other end without the mouth of the Peece, as you ſee the draught: which being well fired, you may diſcharge the ſame at your pleaſure. The ſtring made faſt to the end of the fire-work is to keep the arrow ſtraight in his paſſage, being ſhot either with or againſt the wind.

For the like ſervice aforenamed, it is good to have certaine ſtrong bowes to ſhot firy ſhafts, ſomething ſtronger and longer then ordinary ſhafts, for making the fire-work faſt to them; the which being fired and diſcharged out of the bow by a skilfull Archer, having a ſtrong arme,

will

will do excellent good ſervice for diuers occaſions, as by the draught here-under you may ſée.

I might here adioyn variety of ſerviceable Fire-works, as alſo ſhew many deuices of pleaſant fire-works to be uſed in triumphs before great perſonages, but to the wiſe theſe may ſuffice, who by experimenting theſe may eaſily performe the other.

Here followeth the making and uſe of the Geometricall Inſtrument called the Gunners Quadrant.

THe Quadrant Geometricall is the moſt common and eſpeciall Inſtrument uſed amongſt the profeſſors of the Art of Gunnery, moſt eaſie to underſtand of the unlearned, both for bringing their peece level with any mark they are to ſhoot at, as alſo to ſhoot at any degree of the randon, the effects whereof I haue not ſeen ſet out in any booke of Gunnery; and therefore haue thought good to ſhew ſome notable practiſes by the ſaid Inſtrument to be performed, the making and uſe whereof briefly followeth.

To make a Geometricall Quadrant either of metall or of fine ſmooth wood, draw four equall ſtraight lines that may cut each other ſquare-wiſe of ſeven or eight inches length or more, for the larger the leſſer errour, as you may ſée in the figure A B, B C, C D, D A, following. And from the center A, draw a ſlope line to C. called the hypothemiſall line, and of ſome a diametrall line, upon which, if the plum line fall upon the center A, lok-

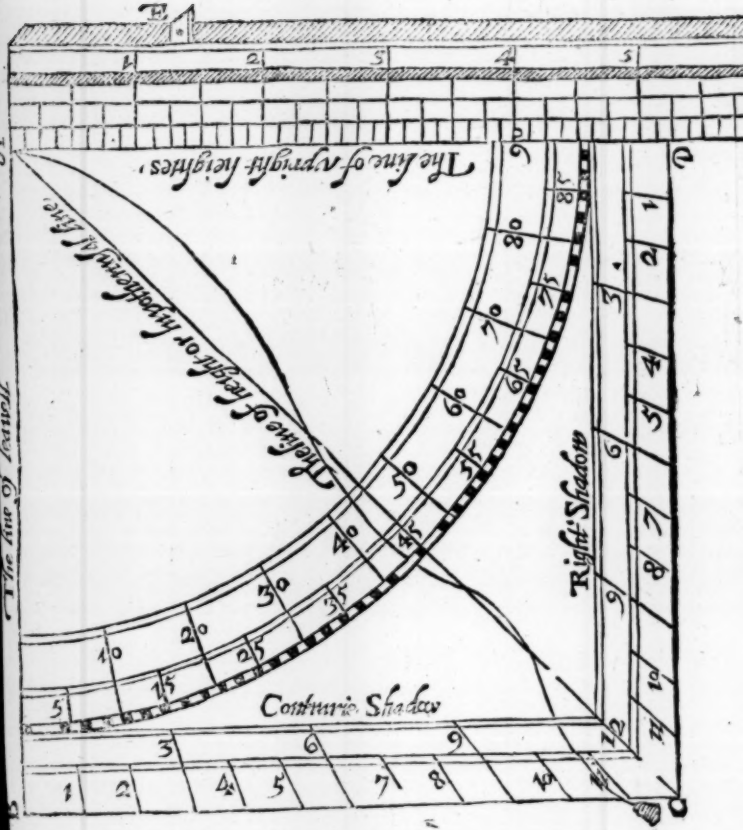
ting through the sights E, F, beholding the extreme or highest part of any altitude, the distance from the middle part of your foot to the base thereof adding thereto the iust heigth from your eye; is the iust heigth of the said altitude: but if the plum line fall on the line A B, then any mark that you view through the visuall sights E F, is of equall heigth or level with your eye. Or putting the rule into the concave of the peece, so that the thred fall on the line A B, then that Peece lieth point blank, or in a streight line with any mark you are to shot at: or if the plum line fall on the line A D, the thing you behold is direct upright; then opening your compasse ỳ iust length of any one of these squire lines, setting one foot in the center A, with the other foot draw an ark or circumference from the angle D to B, which ark shall be ỳ iust one fourth part of the circumference of a circle, and is called a Quadrant, the which is to be divided into ninety equall divisions, which are called degrees; which may easily be done by dividing the ark into three equall proportions, and every of them into three, so have you nine equall parts, so that dividing each of them into two parts makes 18 equall parts, and every of those into five equall parts, will make iust ninety equall divisions or degrees: so is your Quadrant finished.

The scale which is the squire lines B C, and C D, may be divided into 12, 60, yea 100, or 1000 divisions, the more the better, for the use of shadows, lengths, heigths, &c. Where you must remember, that the side C D is called the right shadow, & sheweth how to measure all heigths within the length thereof; but ỳ side B C is of contrary shadow, which serveth to measure all heigths without the length thereof, the use whereof followeth.

The rule to which the Quadrant is artificially ioyned would be 2 foot in length, divided in equall inches and parts, with a hollow slit in ỳ midst, upon which would be placed a fine plate with a little round hole in ỳ middle thereof, to view any mark setting the rule upright at the breach of the Peece: the said plate would be made to move up or down at pleasure, by which you may know what length or what inches & parts any Peece requireth to reach any mark. The visual sights placed on ỳ edge of ỳ rule would not be above 2 or 3 inches from the ends therof, and the rule would be of weight to counterpoize the quadrant, so that when the rule is put into the concave of the Peece, the quadrants weight do not raise the same.

Before you begin to measure the length or heigth of any altitude, or to know whether any mark you are to shot at be higher or lower then your platform, or the cylinder of your Peece, it behoveth you first to see whether the base or lowest part of ỳ said mark or altitude be above or under point blank; the which you may know by viewing the same through the sights on the rule, letting the thred fall at liberty on the degrees of the quadrant. And if the plum line fall on the line of level, then the mark is of equall heigth with your eye; if the thred fall towards you, the mark is above point blank; if from the line of level, it is under point blank. And for the more true and perfect working of the conclusions following, it is good to make a little hollow skrew in the middle of the hypothemisall line, and to have a staffe or Gunners Javelin to erect perpendicularly with a little

skrew



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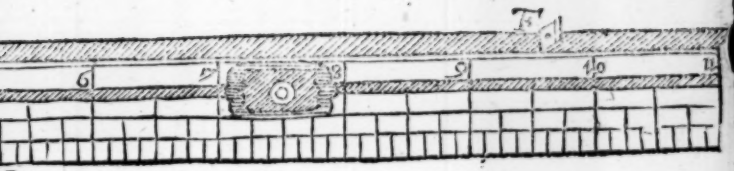
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skrew plate of iron on the end at the side thereof, into which turning a skrewed nayle through the hole so made in the quadrant, you may make the same unmoveable, so as you may lift the same up or down to behold any mark at pleasure; for no man can hold his hand so precisely, but it will shake and move, and so cause the thread to erre a little.

How you may by your Geometricall quadrant measure the heigth of any wall, tower, steeple, tree, or any altitude approchable.

Go towards the same untill by supposition you think you are near about the length of the heigth of ỹ same, & then setting the quadrant to your eye, looking through the visuall sights, beholding the extreme or highest part of the altitude, go to or from ỹ same untill ỹ thread & plummet cut or fall upon the part 12 of right shadow; then measuring how farre it is from ỹ middle part of your foot to the base of the said altitude, thereunto adding ỹ heigth from your eye to the ground, you have the iust heigth of that altitude.

The same conclusion is to be wrought by the shadow or beam of the Sun, in turning the left side of your quadrant to the Sun, so as his beams may pierce through the visuall sights of the plummet falling on the part 12, the distance from the furthest point of the shadow to the base of the altitude is the iust heigth of the same, being an upright altitude.

How you may divers wayes find out any upright height within the length thereof both by the shadow and without shadow.

If the ground be plain, and that you may go so near to the base of the altitude, that the plum line may fall on the part one of right shadow; then measuring the distance from the midst of your foot to the base thereof, multiplying that measure by twelve, and adding thereto the heigth from your eye to the ground, you have the true heigth of that altitude: or letting the Sun beam pierce through the visuall sights of the plum line, falling at liberty on the part one of right shadow, measuring and multiplying that measure by twelve, and dividing by the parts whereon the plum line hangs, the quotient will tell you the true heigth of the same altitude: for this is a generall rule, that look what part of right shadow is cut by the thread or plum line, the altitude or upright heigth to be measured is more then that shadow, by such proportion as twelve exceedeth the part or division of the scale where the thread or plum line was found.

If the thread be found to fall on the part 2 of right shadow, measure the distance from the midst of your foot to the base of the altitude, six times that measure is the heigth of the same, adding the heigth from the eye to the ground, for the part 2 is contained in 12 (the divisions of the scale) six times; or what part soever it fall on of right shadow, look how oft that part is contained in 12, so many times as that measure is from the midst of your foot to the base, ever adding the heigth from your eye, is the true heigth of ỹ thing you measure. Or in brief, if the plum line fal on ỹ part 3, working as is said, four times that measure is the heigth of the altitude.

Or if it fall on the part 4, then three times; if on the part 5, two times ⅔ parts of the shadow is the heigth: if on the part 6, 2 times; if on the part 7, once & ⅔: if on the part 8, once and ½: if on the part 9, once ⅓: if on the part 10, once & 1/10: if on the part 11, once 1/11 part of the shadow. All these measurations be to be wrought within the length of the altitude.

In measuring by the points of contrary shadow, which sheweth to measure all altitudes without the length thereof, you must multiply the length of the shadow by the point or division of the scale whereon the thread falleth, dividing the result by 12, the quotient will shew you the true heigth of the altitude.

Or without shadow, go so neare to the same that you imagine you are neare within the length thereof, lifting up the quadrant orderly, going to or from the same, till through the sights you espy the top or highest part of the altitude, the thread falling on the part 12, standing upright with your body, and at the midst of your foot make a mark, then go directly backward from the same, till through the visuall sights you espy the highest part againe, the thread falling on the part 6 of contrary shadow, and at the midst of your foot make another mark, the distance betwéen those two marks adioyning thereto, the heigth from your eye to the ground, is the true heigth of the altitude; and your furthest station is twice the length of the heigth of the altitude, wanting the heigth from your eye to the ground, which you must ever adde to the work.

Another way.

If at the first station the thread fall on the part 6 of contrary shadow, and at the second station on the part 4, the distance betwéen those 2 marks is the heigth, adding as before, & the furthest station is three times ỳ length of ỳ altitude you measure from ỳ base thereof, the ground being plain.

Another way.

If at the first station the thread fall on the part 4 of contrary shadow, and at the second on the part 3, then the distance betwéen your two standings is the heigth desired, adding as afore, and the furthest station is distant from the base of the altitude four times ỳ length or heigth thereof.

Another way.

If at the first station the thread fall on the part 3, & at ỳ next the part 2, then ỳ distance betwéen those two standings is twice as much as ỳ length of the altitude, excepting the heigth from your eye to the ground, & your furthest station shall be from ỳ base of ỳ altitude 6 times ỳ heigth thereof.

Another way.

If at the first your thread fall on the part 2 of contrary shadow, and at the second on the part one, the space betwéen the 2 standings shall be 12 times the length or heigth of the altitude, or the sixth part of that measure shall be the heigth thereof, and your furthest station shall be distant from the base thereof twelve times the heigth thereof.

And note that if the scale were divided unto 60, 100, or 1000 divisions, by so much further from the thing to be measured might you finde out the heigth thereof.

How

How you may likewiſe by the parts of right ſhadow in the ſcale by the ayde of two places find out any approachable heigth.

PLace your Quadrant handſomely to your eye, till beholding the extreme of the altitude thorow the viſuall ſights, your thread falling on the part 12, and at the middle of your foot make a mark, and going nearer to the baſe of the altitude directly forward, beholding the extream or higheſt part of the altitude, the plummet cutting the part 6, at the middle of your foot make another mark, double that ſpace, and thereto adioyne the height from your eye to your foot, the ſumme is the true heigth of the altitude.

Another way.

Lift up your Quadrant as afore, the plummet cutting the part 12, and going nearer till it cut the part 8, marking the middle of both your ſtandings, meaſure that diſtance, and triple that meaſure, and thereto adde the heigth from your eye, you have the heigth.

Another way.

Let the thread cut the part 12 and 9, marking the middle of both your ſtandings, meaſure the diſtance, quatriple that meaſure, and adde the height from your eye, you have the heigth.

Another way.

If at the firſt ſtation the thread cut the part 12, and at the next ſtation the part 10, ſix times the diſtance of the 2 ſtation is the heigth, adding as aforeſaid.

Or if at the firſt it fall on the part 12, and at the ſecond on the part 1, then 12 times the diſtance of the 2 ſtations is the heigth deſired, adding the from your eye to the ground.

A generall rule how you may by a Gunners Quadrant meaſure all heigths by Arithmeticall skill.

Note what point or diviſion of the skale the thread falleth on, your eye beholding thorow the viſuall ſights of your rule the iuſt top or extream part of the altitude, if the thread fall on the parts of right ſhadow, then multiply the diſtance from the middle of your foot to the baſe by 12, and divide by the parts of the skale wherein the thread fell, adding thereto the heigth from your eye to the ground, you have the heigth. But if the thread fall on the parts of contrary ſhadow, then multiply the diſtance from the middle of your foot to the baſe by thoſe parts, and divide by 12, and to the quotient adde the heigth from your eye to the ground, you have the altitude likewiſe.

Example.

Suppoſe the plum line cut the part 5 of contrary ſhadow, the diſtance

from the middle of your foot to the base of the altitude 110 foot, that multiplyed by 5 is 550 foot, the which divided by 12, yeelds in the quotient 45 foot $\frac{5}{6}$, to which adde 5 foot, the heigth from your eye to your foot, the sum is 50 foot $\frac{5}{6}$ the true heigth of that measure.

Or suppose the threed fall on the part 6 of right shadow, the distance from the middle of your standing to the base of the altitude 24 foot, which multiplyed by 12, makes 288, divided by 6, the quotient is 48 foot, to which 5 foot added, the supposed heigth from your eye to the ground is 53 foot, the heigth of that altitude.

Note in every working, whether the ground at your standing be levell or not with the base of the altitude, if it be either higher or lower then the base, the plum line falling on the line of level, will tell you what part of the base is levell with your eye.

A generall rule to measure the length or distance of the parts or part of any Altitude.

You must first find out the heigth of either part of the thing you would measure, by the rules aforesaid, in taking the length or heigth of the top and base of the same, abating the lesse out of the more, the remain is your desire. Or setting up perpendicularly a Gunners Javelin, Halbard or staffe, divided into equall parts, a little within the length of the heigth of the altitude you would measure, moving your selfe from the same backwards, either lying on your back, or stooping your eye low towards the ground, til you can espy the extream tops or ends of the altitude and staffe in a streight line from your eye, and then not moving your eye, view the lowest part of the same thing you would measure, and suppose the visuall line cut or passe by the third part or division of the staffe, which imagin to bee divided into 8 equall parts, or 8 foot the length thereof; and that the distance from your eye to the base of the staffe is 18 foot, and the distance from your eye to the base of the altitude is 120 foot, frame the rule of 3, saying, if 18 foot the space from your eye to the staffe yeeld 120 foot, which is the distance to the base of the altitude, what will 3 foot: multiply 120 by 3, ariseth 360, divide by 18, the quotient is 20 foot, the heigth of that part of the altitude you desire to measure.

A Rule how by the degrees of the Quadrant by knowing a part or proportion of the base or lowest part of any Altitude to find out the heigth of the same.

Go so neere to the thing whose heigth you would measure, setting the rule to your eye, so as the plum line falling on the line of levell, may point equall with the base of the altitude, or else note some mark of the altitudes base, where your visuall sight points at the threed falling on the line of levell; then raise the quadrant higher, so standing still as the threed may fall

fall on the first degrée thereof, and looking thorow the sights, mark where the visuall line points at, the distance betwixt those two marks is to bee measured. And lastly lifting up your Quadrant, beholding the top thereof thorow the sights, mark upon what degrée the thréd falleth: and so by knowing the distance and heigth of the first degrée, you may easily by the golden rule finde out the heigth of the altitude. Example. Say or suppose the thréd falleth on the sixth degrée of the quadrant: when you beholde the top thereof thorow the visuall sights, and the known distance of one degrée is 8 foot, then say, if one degrée yéld 8 foot, what six? you shall have 48 foot, the true heigth thereof.

How you may by a Gunners Iavelin or Halbard, or any straight staffe, find out any approachable heigth by the shadow.

Suppose the Gunners Iabelin be 8 foot in length, set the same up perpendicularly, and measure the length of the shadow the same casts, which measure suppose to be 12 foot: Then measure the length of the altitudes shadow, which suppose to be 60 foot. Then framing the rule of proportion, saying, if 12 foot known shadow yéld 8 foot heigth, what 60? and so multiplying 60 by 8, and dividing by 12, the quotient is 40, shewing the heigth of the altitude is just 40 foot in heigth, the like rule is in Vegetius.

Another way without shadow by any streight thing perpendicularly erected to finde out the heigth of any approachable Altitude.

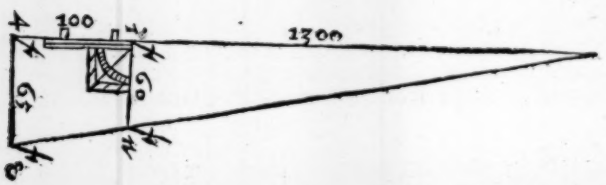
Set up a staffe or Gunners Iabelin perpendicularly as afore, somwhat within the length of the altitude, going from the same, and lying on your back, move your selfe to or from the same, till you can espy the very end of the Iabelin, and the top of the mark in a streight line from your eye: Suppose the distance from your eye to the staffe 12 foot, and the distance from your eye to the base of the altitude 60 foot, and the heigth of the Iabelin 8 foot; say if 12 foot the space from your eye to the staffe yéld 8 foot heigth, what will 60 foot (the distance from your eye to the base of the altitude?) Multiply and divide, your quotient is 40, as afore, shewing the altitude of the thing to be measured. The like rule is in Master Digs his Geometricall Booke called Pantometria, who sheweth also in the same, how by any two staves of equall length joyned in a right angle squirelwise, you may find any altitude, by setting the one end thereof to your eye, going to or from the thing to be measured, untill you can by the points or ends of the other staffe with one eye view both the base and top of the altitude, making a mark at the midst of your foot, the distance from that mark to the base is the just heigth of the thing you séeke to measure.

Many mo wayes there be to find out heigths, both by the Quadrant,

squire, triangle, glasse, staffe, &c. which I let passe: the unexperienced by these few easie conclusions may the sooner attain the rest.

How you may by the help of the Quadrant from any plain platform know the distance therefrom to any mark you are to shoot at.

Lay your quadrant flat upon some low stole, or take a short staffe with a skrew in the end thereof, erecting the same perpendicularly, and put the Quadrant upon the same skrew; then by the edge of the rule turning the same to the mark whose distance you would measure, or thorow the visuall sights on the rule espy the mark, and at your standing set up a Gunners staffe or Jabelin; then turning your body crosse the same, not altering the rule and quadrant by the line of levell, on the edge of the quadrant espy some other mark athwart the first, and set up the second staffe the distance whereof suppose to be 60 foot; then comming to the first station where the quadrant is placed, viewing by the edge of the rule thorow the visuall sights, some other mark in a streight line back from your first station, whose distance suppose 100 feet, and there erect up the third staffe, and so the first and the third staffe will be in a streight line with the mark, then with a squire or removing the quadrant to the 3 station, turning the right angle or line of levell overthwart towards the 2 station, so as the visuall line may be paralell to the line that crosseth from the 1 station to the 2, there set up the 4 staffe, so as the visuall line passing from the same, and running by the second staffe, may crosse the mark or end in a point there with the first visuall line, the distance betwen these two last stations suppose 65 feet, the staves thus placed in order abate 60 feet, the distance betwen the first and second station from 65 the distance betwen the 3 and 4 staves, the remain is 5 for your devisor, then multiply



the said 65 by 100, the distance from the first to the third, ariseth 6500, the which divided by 5 the quotient is 1300 feet, the distance from the first

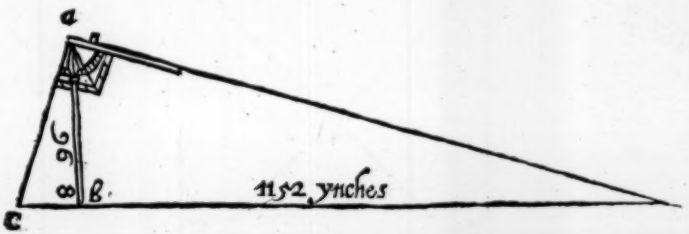
firſt ſtaffe, to the mark. Behold the figure before, where the cypher O, repreſents the mark, the unite 1 your firſt ſtaffe or ſtation, the figure 2 the ſecond ſtaffe, the figure 3 the third ſtaffe, and the figure 4 the fourth ſtaffe.

How you may another way by the quadrant and your Gunners ſtaffe divided into even portions, tell the diſtance to any mark neer hand that you are to ſhoot at.

Set the angle of your Quadrant upon the very point or top of your ſtaffe, the ſaid ſtaffe perpendicularly erected, and thorow the ſights on your ruler eſpy the mark whoſe diſtance you deſire to meaſure, letting a long threed or ſmall line fall to the ground from the center of the quadrant whereon the plum line hangs, which threed muſt be drawn along the line of lebell or edge of the quadrant to the ground, marking where the threed points at on the ground, beholding the mark thorow the viſuall ſights in the rule of the quadrant: and lok what proportion that part of ground betwéen the ſtaffe and where the threed pointed at, hath to the ſtaffe, the ſame proportion ſhall the length to the mark have to the heigth or length of the ſtaffe.

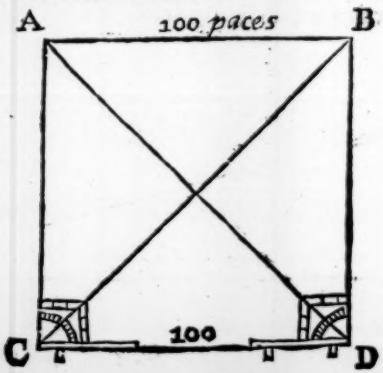
Example.

The Gunners ſtaffe A B, ſuppoſe to be eight fot long, and the diſtance betwéen the ſtaffe and the ground where the threed points you to (being the ſpace C B) is but 8 inches, therefore lok what proportion C B beareth to the length of the ſtaffe (which reduced into inches will be 96 inches) the ſame proportion ſhall the length to the mark D habe to the ſtaffe, which by the Golden rule is thus found. If 8 inches yéld 96 inches, what will 96 inches? multiply 96 by 96 ariſeth 9216 inches, divided by 8, yélds in the quotient 1152 inches, the diſtance from the ſtaffe to the mark: and note that the higher the pole or ſtaffe is, the further may you meaſure by this rule; behold the figure.



How you may by a Gunners Quadrant readily measure the length of any wall or curtaine, or the distance betwixt any two marks in the same.

Go directly towards one of the said marks, that by supposition you are distant from the same about the length betwixt the two marks whose distance you would measure, laying your quadrant flat upon some stole, or placing the same upon the skrew of the staffe aforenamed perpendicularly erected, moving the same to or from the mark you stand against, placing the quadrant so, as the visuall sight passing from the center of the quadrant by the line of levell, may direct you to the said mark, and the visuall line passing from the center of the quadrant by the 12 point or division of the scale which is the hipothemisall line, may direct you to the other mark; and then the length of your standing to the mark which the line of levell directs you to, is from the same iust the distance betwéen the two marks you mean to measure. Then looking athwart by the other edge of the quadrant, or through the sights on your rule, espy some other mark on the ground directly against the mark you meane to measure, and the visuall line passing betwéen your station and the said mark will be paralel to the wall or line passing betwéen the two marks whose distance you would measure. Then removing your quadrant before the other mark, placing the same so as the line of levell may direct you to the said mark, and the line passing by your sights on your ruler may direct you to your first station, the distance betwixt your two stations being measured, is the iust space betwixt the two marks you séek to measure, as the demonstration hereunder sheweth, where the line A B sheweth the length or distance I would measure, supposed to be 100 paces, and the like number is found both in the line C D, as also in the lines C A and D B, which proves the work to be truly wrought.



How

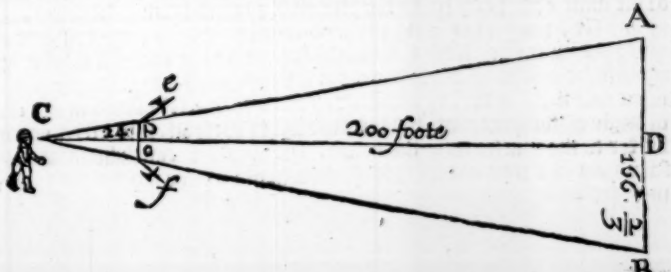
How you may by the former concluſion at one ſtation meaſure the diſtance to both the former marks.

The diſtance from your ſtanding C to the mark A, which the line of level directs you to, is juſt 100 paces, that ſumme ſquared makes 10000 paces. The like number of paces is found in the line A B, being multiplied in it ſelfe: theſe two ſummes being ioyned together, makes 20000 paces, the quadrant rot thereof is 141 paces and almoſt a half, ſhewing the true diſtance from your ſtanding to your farthеſt mark B.

The like order you muſt obſerve to know the juſt length of any ſcaling ladder, to ſcale the wall of any Caſtle, Tower, or Town beſieged, in taking the heigth of the ſaid wall with your quadrant, or otherwiſe as afore hath been taught, multiplying that knowen meaſure in it ſelf, and likewiſe multiplying the diſtance from the foot of the ladder (or the ſpace between the baſe of the wall and that part of ground where the foot of the ladder ſtands) in it ſelf, adding thoſe two ſummes together, extracting the ſquare rot thereof, your quotient will tell you the length of your ſcaling ladder. Or by knowing the length of your ſcaling ladder and the heigth of the wall, multiplying every number in it ſelfe as afore ſaid, abating the leſſer ſumme from the greater, the quadrant rot of the remain is the diſtance of the ground from the foot of the ladder to the baſe of ỳ wall. Or by knowing the length of the ſcaling ladder, and the length of the ground from the foot of the ladder to the baſe of the wall, you may finde out the heigth of the wall in multiplying each number in it ſelf, abating the leſſer ſumme out of the greater, extracting the ſquare rot of the remaine, the quotient will anſwer your demand, as is demonſtrated and proved in the 47 propoſition of the firſt book of Ewclids Elements.

How you may by the aid of two Staves or Gunners Javelins perpendicularly erected, by knowing the diſtance from your ſtanding to the middle part betwixt any two marks, meaſure the diſtance betweene the ſaid marks.

Admit the line A B is the two marks whoſe diſtance I would meaſure, and the line C D is the knowen meaſure to the middle part betwixt the ſaid



marks,